Water Resources Inventory and Assessment

Canaan Valley National Wildlife Refuge

Davis, West Virginia

September 26, 2013

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1 EXECUTIVE SUMMARY

Water Resources Inventory and Assessments (WRIA) are being developed by a national team of hydrologists within the U.S. Fish and Wildlife Service (Service). The purpose of these assessments is to provide reconnaissance-level information on water resources at National Wildlife Refuges (NWRs) and National Fish Hatcheries. The goal of every WRIA is to provide a basic understanding of the water resources that are important to the facility and assess the potential threats to those resources. Data collected in the WRIAs are being incorporated into a national database so water resources can be evaluated nationally and between regions. Information collected for the WRIAs can be used to support Comprehensive Conservation Plans, Hydro-Geomorphic Assessments, and other habitat management plans.

1.1 Findings

1. Average total precipitation for the year in the vicinity of Canaan Valley National Wildlife Refuge is about 56 inches. Precipitation is distributed relatively evenly throughout the year and averages about 4 inches/month.

2. Approximately 21% of the acquisition boundary is considered wetlands using the National Wetland Inventory (NWI) classification system. 59% of the wetland area is classified by NWI as forested/shrub wetlands and 41% is freshwater emergent wetlands.

3. The Blackwater River, Freeland Run, and Gandy Run are all considered water quality limited on the state's 303(d) list of impaired waters.

4. USGS databases identify 26 water quality monitoring sites on, or near, the refuge. However, none of the sites are being actively monitored in 2013.

5. USGS databases identify 27 water quantity monitoring sites on, or near, the refuge. Only two of these sites, stream gaging stations on the Blackwater River, are being actively monitored in 2013.

6. Water use regulations in West Virginia are poised to change in the next year. The West Virginia Department of Environmental Protection is working on developing a statewide water management plan to guide the management and regulation of the state's water resources.

7. Unlike many climate stations in the northeastern U.S., long term climate records near Canaan Valley NWR indicate air temperature has declined approximately 1 degree Fahrenheit (°F) since 1895.

8. Long term records of stream discharge indicate the average annual flow in the Blackwater River has increased about 36 cubic feet per second (cfs) since 1921.

9. A database of active oil and gas wells in West Virginia identifies 3 active gas wells on, or near, the Canaan Valley NWR acquisition boundary.

1.2 Recommendations/Further Actions

The primary threats to water resources at Canaan Valley National Wildlife Refuge are: 1) erosion and sedimentation associated with old logging roads and rail grades; 2) nutrient inputs and changes to runoff patterns in watersheds with residential and commercial development; and 3) possible wastewater spills associated with oil and gas well drilling on and near the refuge.

1.2.1 Inventory and assess logging roads, access roads, rail grades and skid trails

Although many of the largest rail grades and logging roads have been mapped, there are many more throughout the refuge that remain unmapped. This is particularly true in the upland areas on the valley edges. In places these old roads may be detrimentally affecting aquatic habitat by re-directing streamflow, introducing sediment to streams and wetlands, or altering the hydrologic regime of wetlands. An inventory of these features is an important first step for identifying areas that need remediation and was outlined as a strategy for meeting Objective 1.1 of the CCP (USFWS 2011).

1.2.2 Install Water Quality Monitoring Sensors in Selected Refuge Streams

Off refuge development in the southern end of the valley can affect water quality and runoff conditions in refuge streams. The scale of these impacts is not well quantified because there is little continuous water level or water quality monitoring taking place. In 2012, the Service purchased four water quality sensors for continuous measurements of temperature and electrical conductivity. Data collected with these sensors will help the Service assess existing water quality conditions and provide a reference to compare to if future development negatively impacts stream water quality or if future gas exploration results in wastewater releases.

2 INTRODUCTION

This Water Resource Inventory and Assessment (WRIA) Summary Report for Canaan Valley National Wildlife Refuge (NWR) describes current hydrologic information, provides an assessment of water resource issues of concerns, identifies water resource needs, and makes recommendations regarding refuge water resources. The information contained within this report and supporting documents will be entered into the national WRIA database.

Together, the national WRIA database and summary reports are designed to provide a reconnaissance-level inventory and assessment of water resources on National Wildlife Refuges and National Fish Hatcheries. A national team of U.S. Fish and Wildlife Service (Service) Water Resource staff, Environmental Contaminants Biologists, and other Service employees developed the standardized content of the national WRIA database and summary reports.

The long-term goal of the National Wildlife Refuge System (NWRS) WRIA effort is to provide up-to-date data on a facility's water quantity and quality in order to protect adequate supplies of clean and fresh water. An accurate water resources inventory is essential to prioritize issues and tasks, and to take prescriptive actions that are consistent with the established purposes of the refuge. Reconnaissance-level water resource assessments evaluate water rights, water quantity, known water quality issues, water management, potential water acquisitions, threats to water supplies, and other water resource issues for each field station.

WRIAs are recognized as an important part of the NWRS Inventory and Monitoring (I&M) Program and are outlined in the I&M Draft Operational Blueprint as Task 2a. Hydrologic and water resource information compiled during the WRIA process will help facilitate the development of other key documents for each refuge including Hydrogeomorphic Analyses (HGM) and Comprehensive Conservation Plans (CCP).

2.1 Canaan Valley NWR WRIA

This WRIA Summary Report for Canaan Valley NWR incorporates hydrologic information compiled between May 2012 and July 2013. The report is intended to be a reference for ongoing water resource management and strategy development. However, the document is not meant to be exhaustive or a historical summary of activities on Canaan Valley NWR. This WRIA was developed in conjunction with refuge staff under a contract with Atkins North America, Inc. in 2012 and 2013.

3 FACILITY INFORMATION

3.1 Canaan Valley National Wildlife Refuge

Canaan Valley National Wildlife Refuge (NWR) (referred to as the refuge) is located in eastern Tucker County, West Virginia in the Allegheny Mountains (Figure 1). The refuge was established on September 11, 1994 "to ensure the ecological integrity of Canaan Valley and the continued availability of its wetland, botanical and wildlife resources to the citizens of West Virginia and the United States" (USFWS 2011). Authority for managing and acquiring the land for the National Wildlife Refuge System falls under the Migratory Bird Conservation Act of 1929, Fish and Wildlife Act of 1956, and the Emergency Wetlands Resources Act of 1986. The largest wetland complex (over 8,400 acres) in both West Virginia and the central and southern Appalachian Mountains is found in the Canaan Valley and 5,573 acres are located within the refuge. Also, several threatened and endangered species are found on the refuge, including the Indiana bat and the Cheat Mountain salamander (USFWS 2011).

The acquired boundary of the refuge encompasses 16,456 acres[1] (within a 24,892-acre acquisition boundary). The landscape is composed primarily of upland forest (northern hardwood), freshwater wetland (shrub, herbaceous) and upland early successional (old field) habitats (USFWS 2011).

[1] Refuge acreage is based on GIS analyses using 2012 data available at the beginning of this project. More recent (May 2013) GIS data of the refuge boundary has a slightly different acreage (16,550 acres).

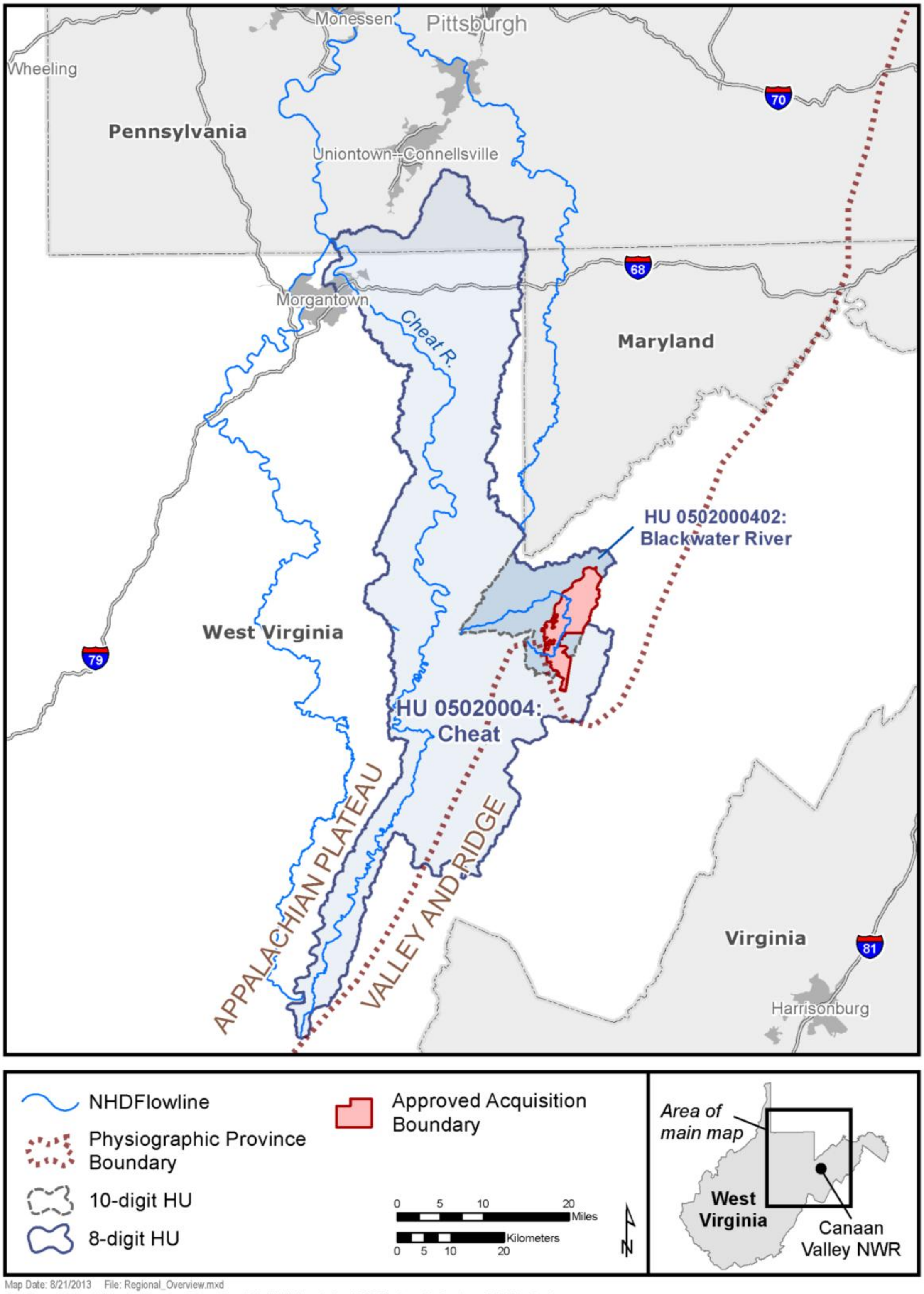


Figure 1. Regional overview map showing Canaan Valley NWR location in relation to the Appalachian Plateaus and Valley and Ridge physiographic provinces.

4 NATURAL SETTING

4.1 Topography and Landforms

The refuge lies in the Allegheny Mountain Section of the Appalachian Plateau physiographic province, which is characterized by rounded ridges separated by broad valleys. Relief between the ridge crests and the adjacent valley lowland can be greater than 1,000 feet, but relief on the valley lowland is generally less than 500 feet. The Canaan Valley is the highest valley of its size east of the Rocky Mountains with an average elevation of 3,200 feet above sea level. The average elevation of the ridges is 3,900 feet though some peaks exceed 4,200 feet (Figure 2) (USFWS 2011).

The U.S. Geological Survey (USGS) has developed a national dataset of hydrologic units (Seaber et al. 1994). Hydrologic units are based on watershed boundaries and are assigned Hydrologic Unit Codes (HUC). Two-digit HUCs are applied to the largest areas, which are defined as regions. Regions are subdivided into 4-digit subregions, which are then further subdivided down to smaller areas. For the purposes of this WRIA, HUCs at the 8-digit (subbasin) and 10-digit (watershed) scales will be referenced.

Canaan Valley NWR is located within the Cheat (8-digit HUC: 05020004) subbasin and the Blackwater (10-digit HUC: 0502000402) watershed (Figure 1).

4.2 Geology

Canaan Valley was formed by a breached anticline and the erosion of the crest of a ridge of upward folded rocks. Rocks in the center of the breach form the valley floor and are eroding more quickly that those at the valley outlet. The different erosion rates contribute to the valley's low relief which creates conditions favorable for peat accumulation and wetland formation (Chambers et al. 2002). Because of this erosion pattern, the exposed rock layers in the middle of the valley are older than the rock layers at the valley edge.

The Canaan Valley is underlain by Mississippian Epoch sedimentary rock of the Pocono, Greenbrier, Mauch Chunk and Pottsville groups (Figure 3, Figure 4). The "middle ridge" portion of the valley is composed of Pocono sandstone, also known as the Price Formation. Pottsville sandstone forms the ridges surrounding the valley and overlies the shale and coal of the Mauch Chunk group. Greenbrier limestone underlies most of the valley and depressions in the limestone have created unique wetland communities (USFWS 2011). The bedrock is overlain by a discontinuous layer of unconsolidated deposits (i.e., weathered rock, alluvium and wetland peat and clay) between 0 and 30 ft deep (Kozar 1996).

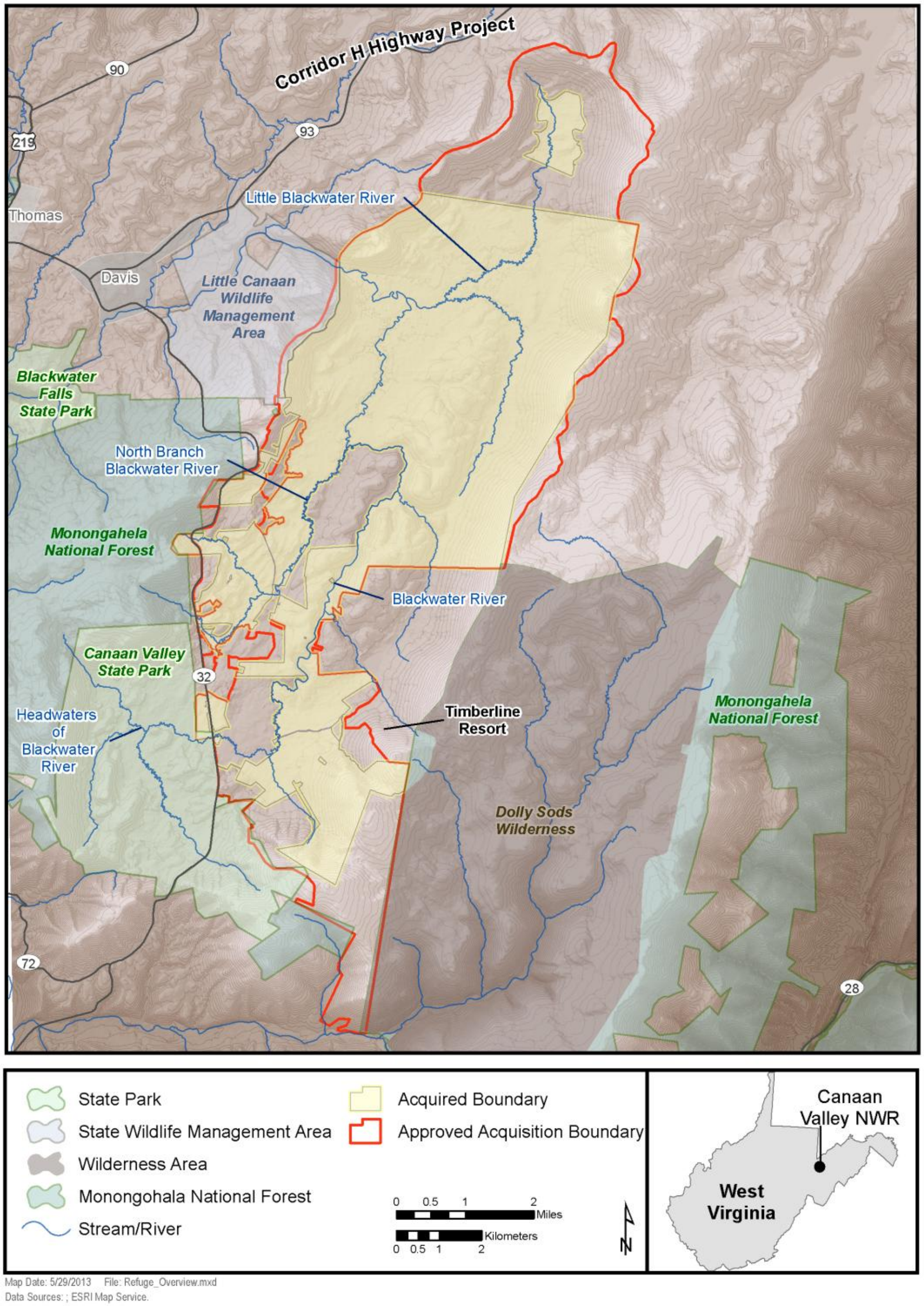


Figure 2. Location detail of Canaan Valley NWR and nearby federal and state protected areas.

4.2.1 Mining Activity

Coal mining is widespread in West Virginia and occurs in several areas north, east and west of the Canaan Valley (Matchen et al. 1999). Most coal mining near the refuge occurs in the Connemaugh Group rocks which are geologically younger than those found in Canaan Valley (Figure 4).

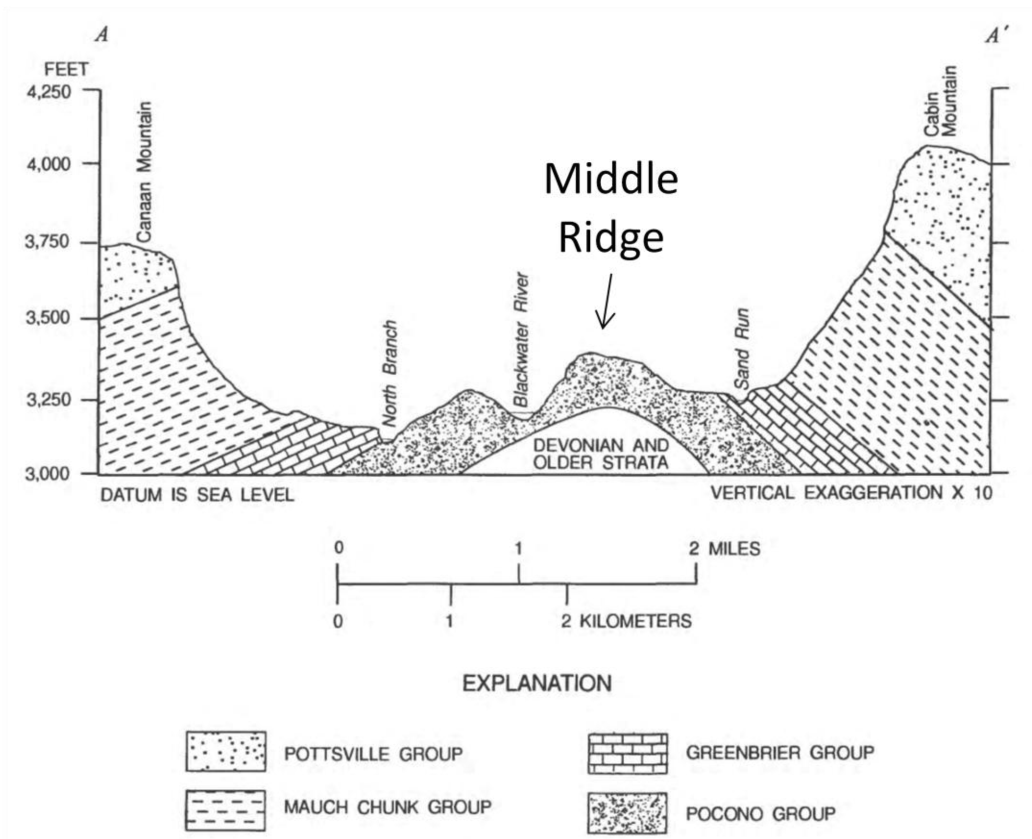


Figure 3. Generalized geologic section of Canaan Valley, West Virginia (modified from Kozar 1996).

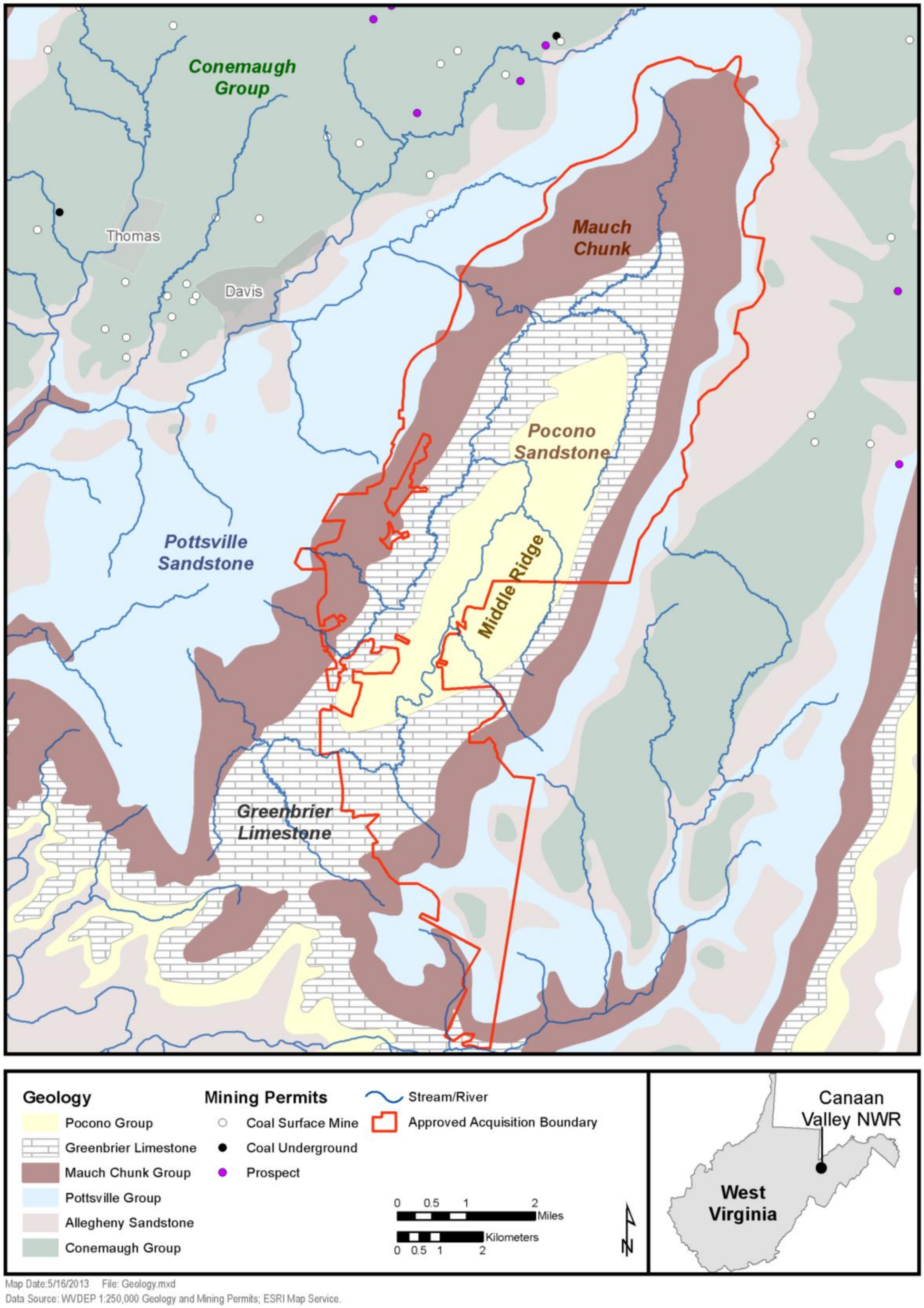


Figure 4. Geology and coal mining permits around Canaan Valley NWR.

4.3 Soils

The U.S. Department of Agriculture, Natural Resource Conservation Service (NRCS) conducted a soil survey of Tucker County and the Canaan Valley in 1967 and identified five physiographic categories: uplands, lower slopes, floodplains, stream terraces and swamps (Losche and Beverage 1967). The upland sites are well-drained or excessively drained, whereas soils in the lower floodplain, stream and swamp areas (muck and peat soils) are mostly poor to very poorly drained. Canaan Valley contains the largest expanse of wet terrace land (Blago and Atkins soil series) and muck and peat soils in Tucker County (USFWS 2011). Approximately 35% of soils in the refuge acquisition boundary can be classified as hydric or partially hydric (Table 1, Figure 5). Hydric soils are defined as: "soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part" (USDA 2006). These soils are found in wetlands (Richardson and Vepraskas 2001) and their extent often mirrors the extent of wetlands in a particular area. "Partially hydric" soil types have been identified by the NRCS as having better drainage than hydric soils and are also common in wetland areas.

The Canaan Valley contains some high quality peat deposits in bedrock depressions on terraces in the northern portion of the valley (Cameron 1970). Peat is composed primarily of sphagnum and reed sedge material and is between 1.5 and 3 m thick (Cameron 1970). The approximate location of peat deposits identified by NRCS is illustrated in Figure 5 (NRCS, 2013).

Table 1. Hydric classification of soils within Canaan Valley NWR acquisition and approved boundaries.

Hydric Classification	Acres within Acquisition Boundary	Acres on Refuge
All hydric	421.8	197.2
Not hydric	16066.6	9332.1
Partially hydric	8404.5	6927.4
Total	***24892.9***	***16456.6***

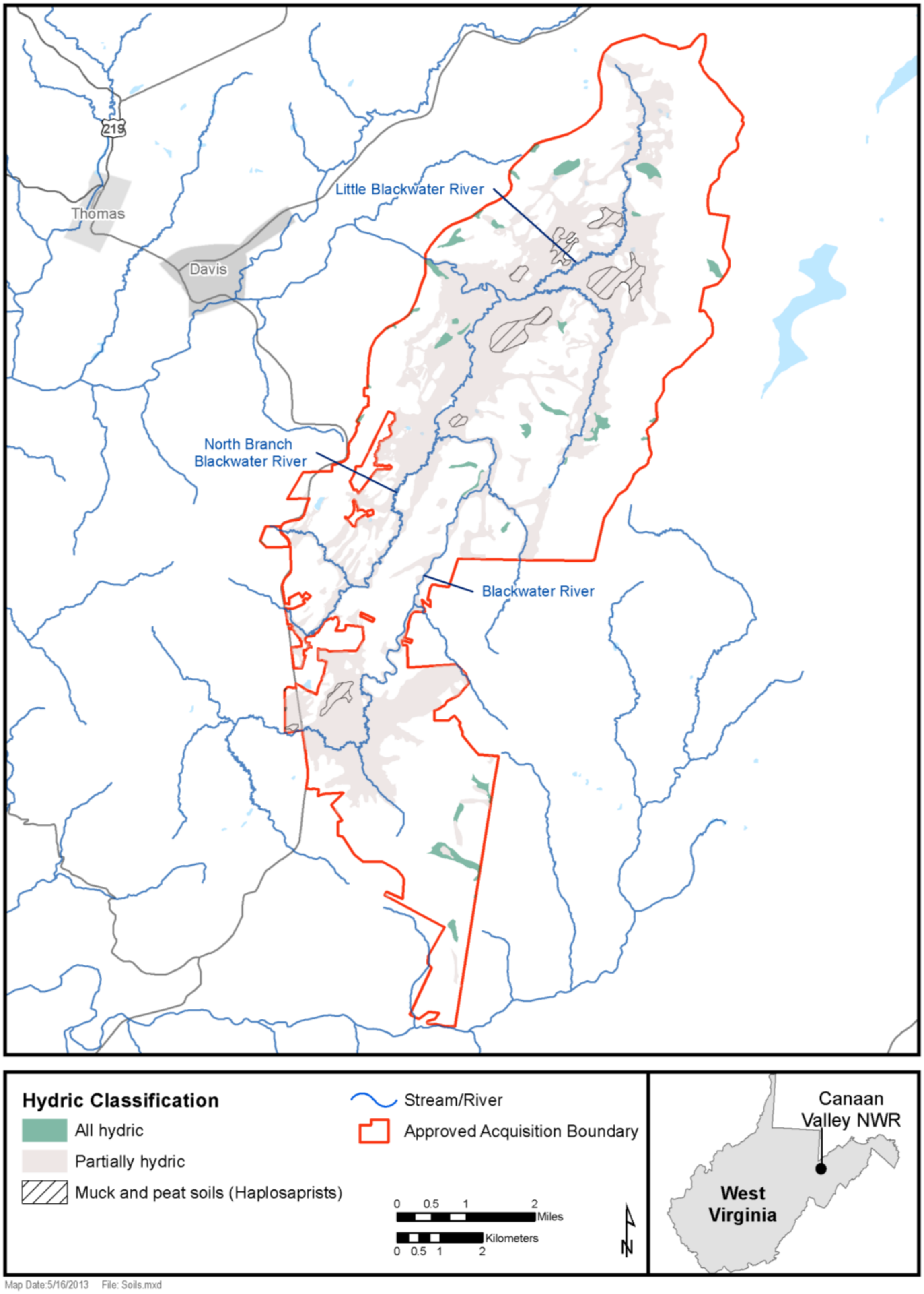


Figure 5. Hydric soil classifications within the Canaan Valley NWR acquisition boundary.

4.4 Hydro-climatic setting

Canaan Valley is the highest valley of its size east of the Mississippi River in North America with an average elevation of 3,200 feet above sea level. As a result of its location at the crest of the Allegheny Mountains on the windward side of the eastern Continental Divide and bowl-like topography, the valley is classified as a cold humid type climate (Vogel and Leffler 2002).

4.4.1 Precipitation Patterns

The U.S. Department of Agriculture's official climatological data comes from the PRISM (Parameter-elevation Regressions on Independent Slopes Model) climate mapping system, developed by Dr. Christopher Daly, of the PRISM Climate Group at Oregon State University. PRISM is a unique knowledge-based system that uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of monthly, yearly, and event-based climatic parameters. Data are continuously updated, and can be downloaded for a specified region, or by latitude/longitude.

The 1971-2000 climatological normals for the refuge indicate an annual average of over 56 inches of precipitation, distributed relatively evenly throughout the year. Temperatures range from an average minimum of 15°F in January to an average maximum of 76°F in July (Table 2).

The average annual snowfall at Thomas, WV is 97.3 inches between 1930 and 1995 (Table 3). Although snowfall is measured at other stations in the center of the valley, Vogel and Leffler (2002) suggest precipitation measurements from the Thomas station are more accurate because the gauge is protected from strong winds.

Table 2. PRISM Monthly Normals (1971 – 2010) for -79.413471, 39.111415 (PRISM Climate Group 2010).

Month	Precipitation (in)	Max Temperature (F)	Min Temperature (F)
January	4.49	34.23	14.94
February	4.11	37.49	16.93
March	4.69	46.09	23.72
April	4.68	57.09	31.84
May	5.47	66.51	41.27
June	5.33	73.29	48.96
July	5.76	76.39	53.67
August	4.86	75.38	52.03
September	4.05	69.17	45.64
October	3.83	58.98	34.97
November	4.54	47.88	27.34
December	4.67	38.5	19.18
Total Precipitation	**56.49**		
Average Temperature		**56.75**	**34.21**

Table 3. Average monthly snowfall at the National Weather Service station at Thomas, WV over the period of record (1930 – 1995). Downloaded from http://weather-warehouse.com.

Month	Average Snowfall (in)
January	21.9
February	20.2
March	18.1
April	7.2
May	0.2
June	0.0
July	0.0
August	0.0
September	0.0
October	1.1
November	10.0
December	18.6
Total	**97.3**

4.4.2 Streamflow Patterns

The closest long-term USGS stream gage to Canaan Valley NWR is on the Blackwater River at Davis, WV. The station has a period of record from 1921 to 2013 and runoff patterns at the gage are thought to represent natural flow patterns on streams in the vicinity of Canaan Valley NWR

Runoff in the Blackwater River shows a strong snowmelt runoff response, with streamflow peaking in March of the year. Once the snow has melted, the flow rate drops considerably, eventually reaching the lowest flows of the year in August and September, at the end of the growing season (Figure 6). The average annual discharge on the Blackwater River at Davis is approximately 205 cubic feet per second (cfs).

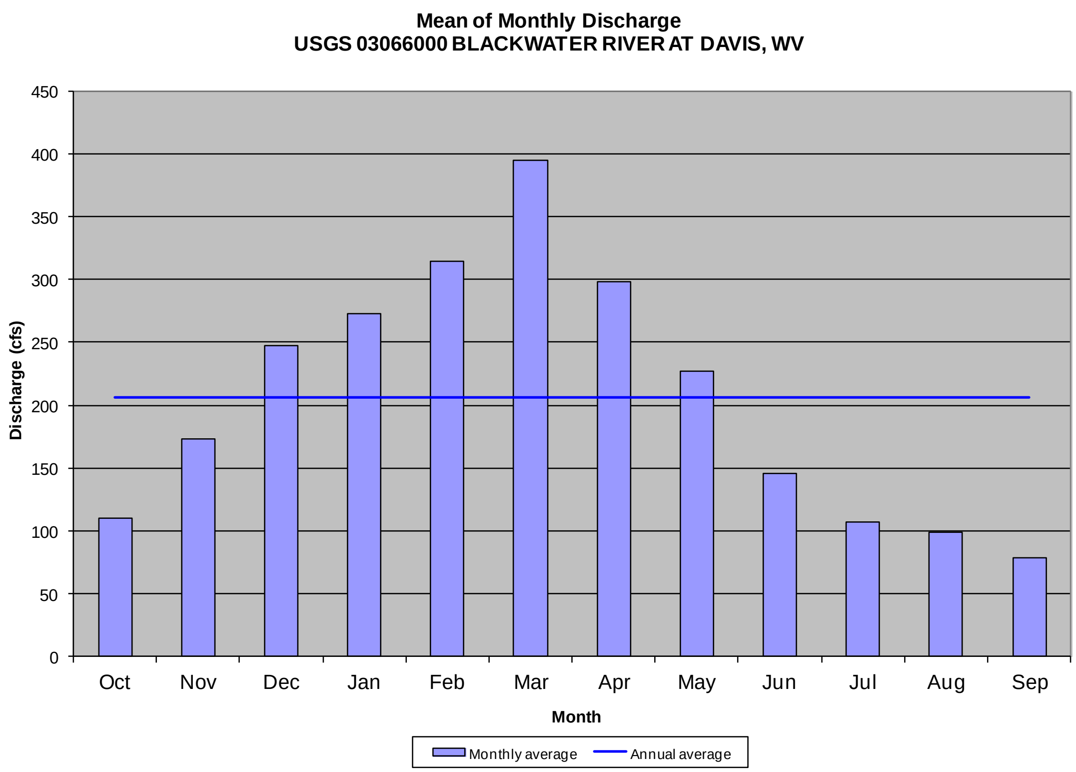


Figure 6. Average monthly discharge from the Blackwater River at Davis, WV. From data collected between 1921 and 2012.

5 INVENTORY

This section of the WRIA summarizes basic information on a refuge's water resources, water-related infrastructure, water quality, water monitoring, water rights, and climatic trends. Data from this section is incorporated into the national WRIA database. Data on waterbodies from the National Hydrography Dataset (NHD) are presented in Section 5.2. Because of the coarse scale of these data, they are not expected to be a perfect representation of stream and water body locations.

5.1 Water Resources

Surface water features include lakes, ponds, springs, impoundments, reservoirs, rivers, streams, and creeks. Groundwater resources include regional and local aquifers that are important to the surface water resources of the refuge. Also included are wetlands identified in National Wetland Inventory maps that cover the refuge area.

5.1.1 Rivers / Streams / Creeks

In the absence of more specific information, the WRIA relies on the USGS 1:24,000 scale NHD to inventory streams at Canaan Valley NWR (Table 4, Figure 7). The focus of the preliminary analysis is on named NHD features because they tend to be the largest and, theoretically, of most interest to Service facilities.

The refuge acquisition boundary encompasses 85 miles of rivers, creeks, and streams, including a 15-mile segment of the Blackwater River. Though not named in the NHD, the refuge encompasses most of Idleman's Run, which has an important brook trout fishery.

Table 4. Named creeks and streams from the USGS 1:24,000 National Hydrography Dataset. Includes features on or within Canaan Valley NWR's approved acquisition boundary.

GNIS Name	Miles within Acquisition Boundary	Miles on Refuge
Unnamed Streams	43.7	35.5
Blackwater River	15.3	10.5
Flat Run	2.2	2.0
Freeland Run	1.7	1.0
Gandy Run	0.3	0.0
Glade Run	5.7	5.7
Little Blackwater River	7.5	6.2
North Branch Blackwater River	7.0	4.9
Sand Run	1.6	1.6
Yoakum Run	0.5	0.4
Total	***85.2***	***67.6***

5.1.2 Drainage Ditches

There are numerous small ditches associated with rail grades and old logging roads on the refuge. These are discussed in more detail in Section 5.2.5.

5.1.3 Lakes and Ponds

According to the NHD there are 76.2 acres of lakes or ponds within the refuge acquisition boundary, however none of them are named. These include natural beaver ponds (both active and abandoned) and manmade settling ponds. The CCP states there are approximately 20 large ponds (beaver ponds and other open water) totaling approximately 93 acres. Pond acreage is highly variable from year to year depending on beaver activity (USFWS 2011). Beaver ponds have increased over the years; analysis of aerial photography showed 113 beaver ponds in 1945 and 222 in 2003 (Bonner 2005, 2009). Beaver activity has impounded drainages on the refuge to create ponds of various sizes and old beaver ponds have developed into palustrine wetlands and bogs. There is a large complex of beaver ponds with rare plant communities along Glade Run in the northeast portion of the refuge (USFWS 2011).

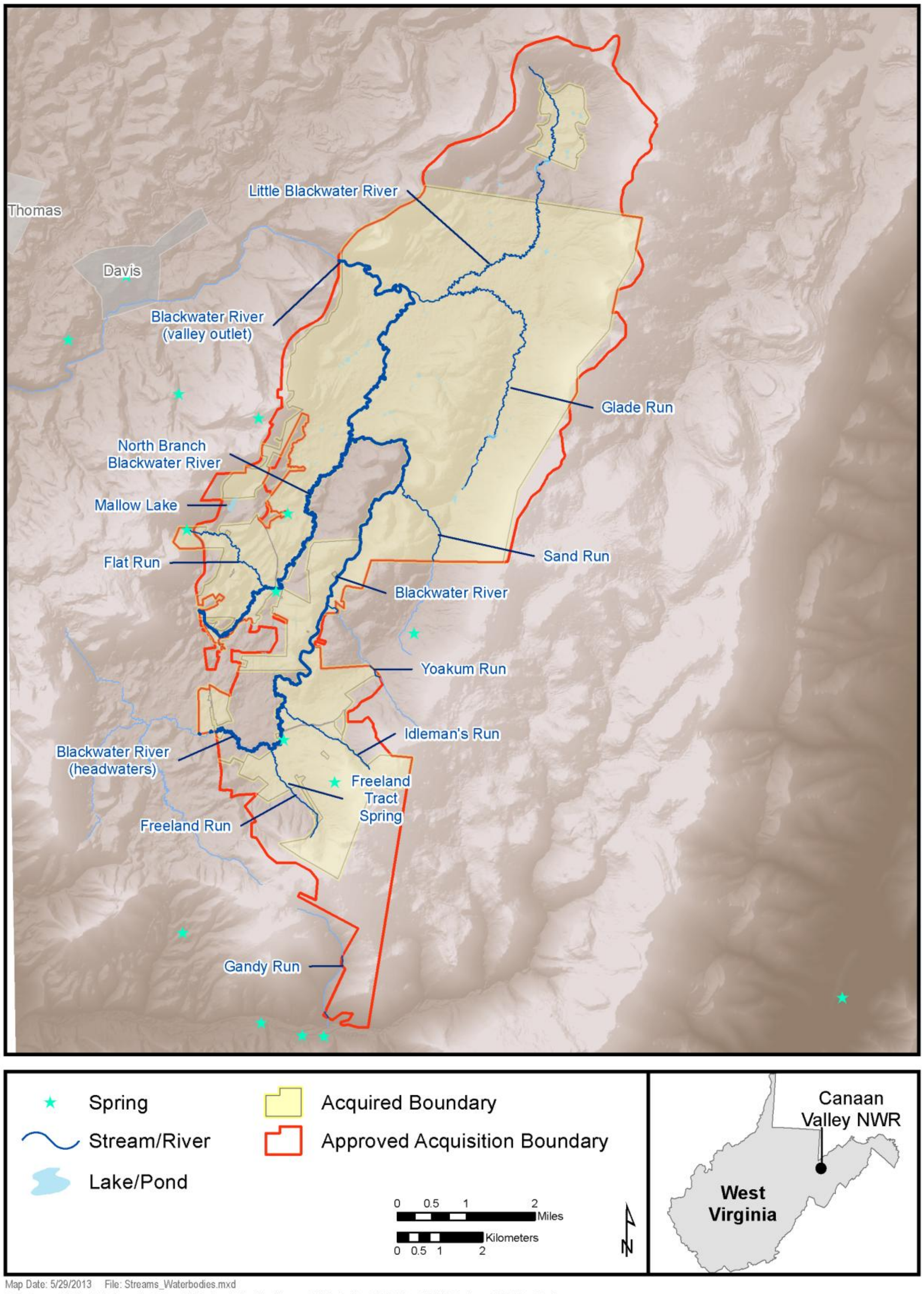


Figure 7. Named creeks, streams and waterbodies from 1:24,000 USGS National Hydrography Dataset (NHD) in the Canaan Valley NWR acquisition boundary.

5.1.4 Springs and Seeps

Canaan Valley NWR contains numerous springs that are considered important water resources at the refuge. Figure 7 shows large springs (greater than 100 gallons per minute [gpm]) included in the West Virginia Department of Environmental Protection's (WVDEP) springs database and those included in the USGS' National Water Inventory System (NWIS) database. There are numerous smaller springs that feed the Blackwater River and create wetlands and small ponds; however, these springs are not mapped in the NHD. Of note is a spring that feeds a series of small beaver ponds on the Freeland Tract, providing waterfowl resting and feeding habitat during the winter when other areas are frozen (Figure 7). Many springs are concentrated in the southern portion of the refuge, where the Greenbrier limestone is near the ground surface. These springs form the headwaters of small streams and provide refugia for brook trout (USFWS 2011).

Seasonal seeps are not represented in the NHD but are important because of their high ecological value. Mapping these small springs and seeps is a top priority for the refuge but has not begun yet.

5.1.5 Wetlands

The Canaan Valley contains the largest wetland system in West Virginia, with the majority of wetlands in the northern portion of the valley. It also represents the southern extent of the bog natural community range. Many rare plant communities are found in refuge wetlands and beaver ponds (Bartgis and Berndine 1991, Byers et al. 2007, USFWS 2011). Ombrotrophic (hydrologically-isolated) bogs occur in undisturbed portions of larger wetlands. More centrally located wetlands, or those that are flood- or beaver-influenced, consist of shrub swamps, sedge fens, wet meadows and open marshes (Byers et al. 2007). Forested swamps occupy a small percentage of the area they covered prior to extensive logging between 1880 and 1920 and remain threatened due to beaver activity.

The National Wetland Inventory (NWI) is a branch of the Service established in 1974 to provide information on the extent of the nation's wetlands (Tiner 1984). NWI produces maps of wetland habitat as well as reports on the status and trends of the nation's wetlands. Using the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979) wetlands have been inventoried and classified for approximately 90% of the conterminous United States and approximately 34% of Alaska. Cowardin's classification places all wetlands and deepwater habitats into 5 "systems": marine, estuarine, riverine, lacustrine, and palustrine. Most of the wetlands in the United States are either estuarine or palustrine (Tiner 1984). The predominant wetland classes at the refuge are defined in Cowardin et al. (1979) as:

> **Riverine:** The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5 ‰. A channel is "an open

> conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water" (Langbein and Iseri 1960:5).
>
> **Palustrine**: the Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean derived salts is below 0.5% (e.g., inland marshes, bogs, fens, and swamps).

The different systems can be broken down into subsystems, classes and hydrologic regimes based on the wetland's position in the landscape, dominant vegetation type, and hydrology.

Approximately 21% (5,191 acres) of the land in the acquisition boundary is considered freshwater wetland using NWI's classification. Of the NWI wetland acreage, 59% is freshwater forested/shrub wetlands (3,076 acres) and 41% is freshwater emergent wetlands (2,168 acres) (Table 5 and Figure 8).

Table 5. Wetland habitat delineated by the National Wetland Inventory inside the Canaan Valley NWR approved acquisition boundary.

Wetland Type	**Acres within Acquisition Boundary**	**Acres on Refuge**
Freshwater Emergent Wetland	2168.1	2119.3
Freshwater Forested/Shrub Wetland	3075.9	2438.5
Freshwater Pond	47.4	32.3
Riverine	0.04	0.0
Total	***5291.5***	***4590.1***

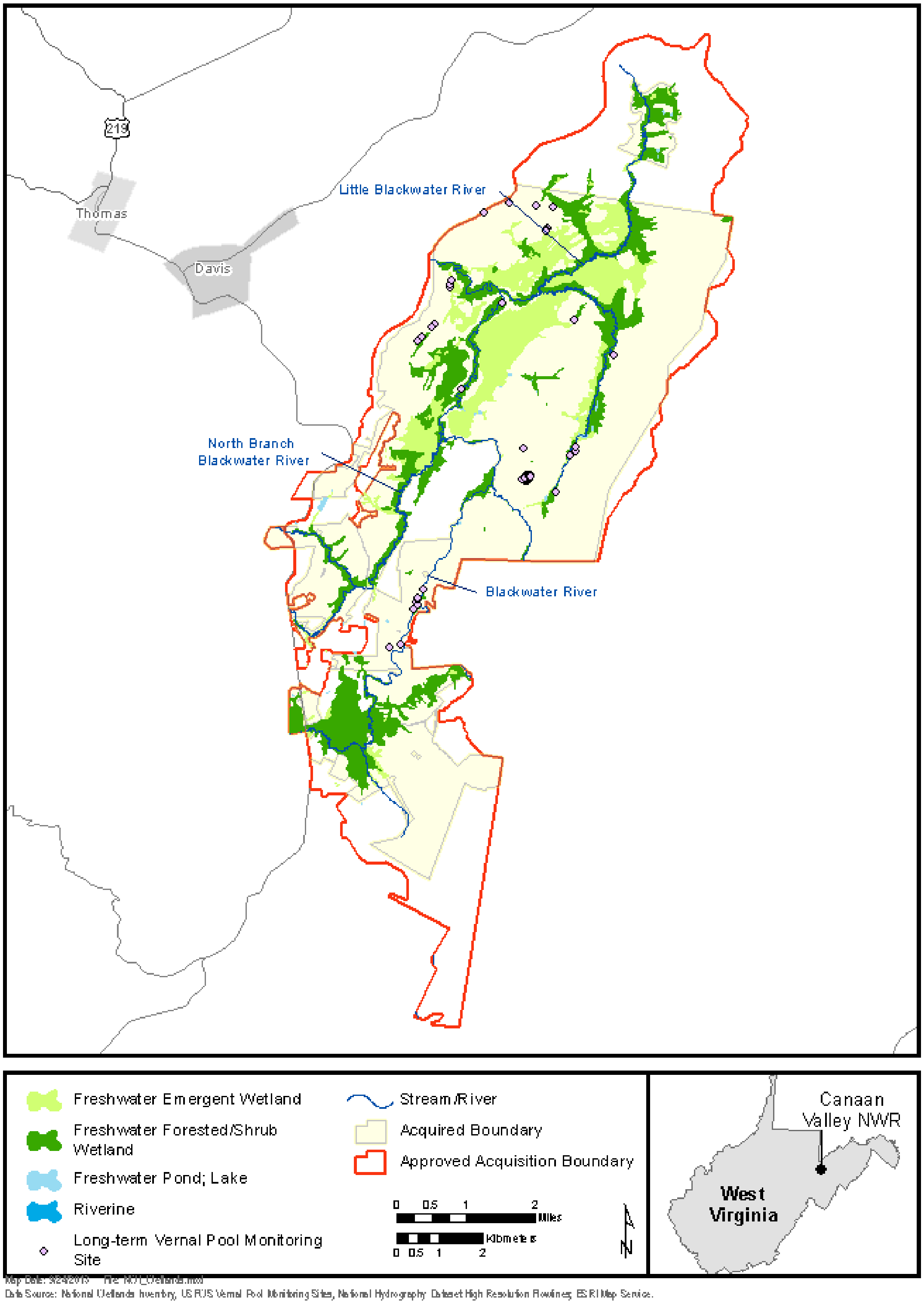


Figure 8. National Wetland Inventory wetlands in the Canaan Valley NWR acquisition boundary.

5.1.6 Vernal Pools

Vernal pools are small wetlands that fill with water during the winter months and dry up during the summer (Mitsch and Gosselink 2000). The seasonal drying makes vernal pools unsuitable for fish populations. The absence of fish reduces predation which makes vernal pools ideal habitat for amphibians. The U.S. Fish and Wildlife Service is partnering with the USGS' Amphibian Monitoring Research Initiative (ARMI) to collect information on amphibian populations at vernal pools on refuges in Region 5. Canaan Valley NWR is part of this monitoring effort and refuge staff have been collecting data at 50 vernal pools on the refuge since 2005 (Figure 8).

Most vernal pools at Canaan Valley NWR are formed where water ponds on the upstream side of old roads and rail grades. Pools form where the roads act like dams and block the natural movement of water in small drainages.

5.1.7 Groundwater

Canaan Valley NWR overlies an area of the Appalachian Plateaus aquifer system. This aquifer system is described generally in the Ground Water Atlas of the United States (Trapp and Horn 1997). A more detailed review of the groundwater hydrology near the refuge is found in Geohydrology and Ground-Water Quality of Southern Canaan Valley (Kozar 1996).

Groundwater in the Canaan Valley is found in the four major rock units under the valley (Figure 4) and groundwater aquifer zones are defined by the different rock units: Pottsville/Mauch Chunk, Greenbriar, Greenbriar/Pocono, and Pocono. Geologic processes have produced fractures in the rocks and these fractures create voids where water is stored in the aquifer zones (Kozar 1996). The network of fractures extends across the different aquifer units creating a continuous unconfined aquifer underlying the valley (Figure 9). The fracture network density is highest near the ground surface, which ensures precipitation falling in the valley recharges the aquifers quickly (Kozar 1996).

The Greenbriar aquifer zone is of particular interest because it is a limestone aquifer and appears to influence streamflow conditions in the Blackwater River. Because limestone is soluble in water, fractures in the bedrock become enlarged over time facilitating the storage and movement of water (Fetter 1994). The larger, more extensive fracture network in the Greenbriar ensures that precipitation recharges the aquifer rapidly and groundwater discharges from the aquifer into the rivers, streams, and springs of the Valley (Kozar 1996). The influence of the Greenbriar aquifer is most pronounced in the southern half of the valley, where the aquifer is more exposed at the ground surface (Figure 4).

Kozar's (1996) study indicates that groundwater discharge to streams makes up a larger percentage of total stream flow in the southern part of the valley compared to the northern part of the valley. Kozar attributed the greater influence of groundwater in the southern end of the valley to the more extensive presence of the Greenbriar limestone aquifer. The less permeable Pocono sandstone is more extensive in the northern portion of the valley, which means less of the water falling as precipitation infiltrates into the aquifer and more contributes directly to stream runoff.

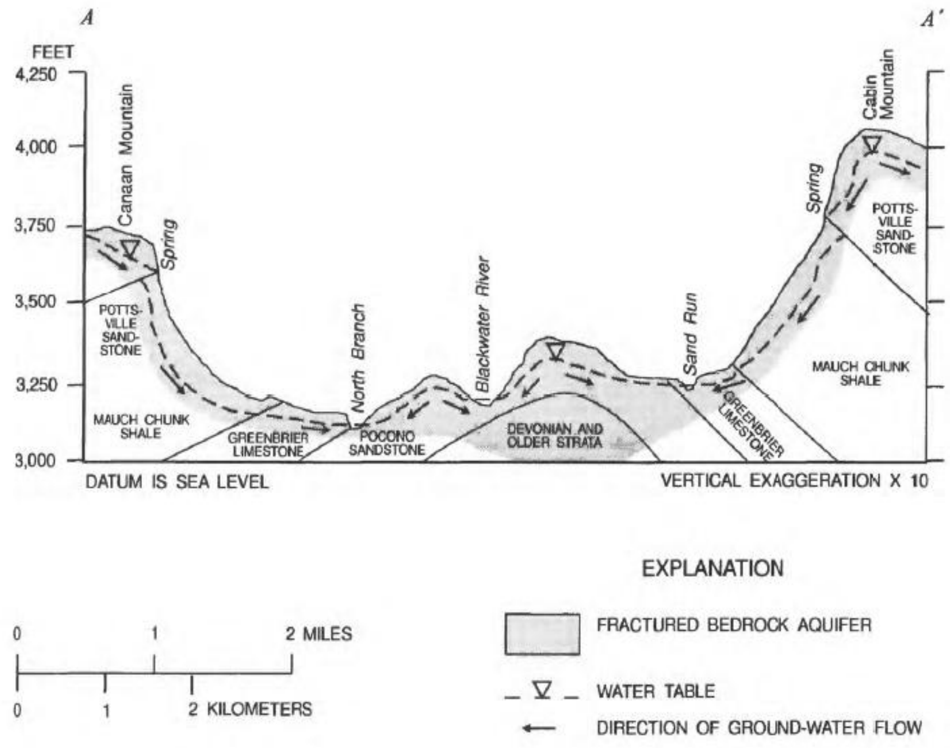


Figure 9. Conceptual movement of groundwater in Canaan Valley (from Kozar 1996).

5.2 Water Related Infrastructure

Water-related infrastructure refers to the assets at a refuge that create or support refuge water resources and objectives. Examples include impoundments for waterfowl habitat, water control structures and water supply wells used to maintain wetland habitat. Many of these types of features are accounted for in the National Wildlife Refuge System's Service Asset Maintenance Management System (SAMMS) database. The aim of the WRIA is to summarize information and provide additional context on a refuge's water resource infrastructure.

5.2.1 Impoundments

There are no impoundments at Canaan Valley NWR.

5.2.2 Water-control structures

There are no water-control structures at Canaan Valley NWR

5.2.3 Off-Refuge Surface Water Diversions

Kozar (1996) estimated that 199.4 million gallons of water are diverted from the Blackwater River and its tributaries each year, and over one-third of available surface water resources are being used during periods of low flow. The majority of diverted water is used for public water supply at facilities serving skiers, hikers, campers and other recreationalists (94%), with the remainder being withdrawn by residential users. Unfortunately this review did not uncover explicit details about the magnitude and location of diversions. Although the WVDEP tracks "large quantity users" (anyone diverting more than 750,000 gallons per month) they do not disclose the locations of these diversions for safety reasons (Jennifer Bannister, WVDEP, personal communication).

In Canaan Valley, Canaan Valley State Park and Timberline Four Seasons Resort are the only large quantity users registered with WVDEP (Jennifer Bannister, WVDEP, personal communication). Water at these facilities is used for public water supply and comes primarily from groundwater wells and diversions from the Blackwater River. Canaan Valley State Park diverts water year-round from the Blackwater River for snow-making, golf course irrigation and water supply for its lodge and facilities (Canaan Valley NWR staff, personal communication).

In addition to diversions from groundwater aquifers, Timberline Four Seasons Resort has a permit to divert surface water from the upper reaches of Idleman's Run to supply water for emergency snow-making (Figure 10). The resort's diversion structure removes enough water from the stream to dry it in the late summer and early fall. The refuge is working with Trout Unlimited to re-design the structure and improve late summer runoff below the diversion (Canaan Valley NWR staff, personal communication).

Sand Run Lake (36 acres) and Spruce Island Lake (42 acres) are two reservoirs located on Timberline Four Seasons Resort in the headwaters of Sand Run and Yoakum Run, respectively (Figure 10). The reservoirs are used to supply water for snow making at the resort during the winter months and affect the creeks downstream by reducing runoff and increasing water temperatures. Additionally, they may be a source of invasive species in Yoakum Run and Sand Run (Canaan Valley NWR staff, personal communication). The impacts of these reservoirs is a particular concern on Sand Run, in 2001 it was one of the few remaining streams in West Virginia where redside dace were found.

Surface water diversions for hydraulic fracturing (i.e., fracking) are also a concern for the refuge. Trucks have been observed pumping water directly from streams for injection into natural gas wells (Canaan Valley NWR staff, personal communication). West Virginia DEP requires permits to use water for hydraulic fracturing if the mining company uses more than 750,000 gallons of water in the well. However, WVDEP is unable to provide information on where diversions for fracking are taking place.

5.2.4 Off-Refuge Surface Water Sources

The Blackwater River is the primary water resource feature in the Canaan Valley. The headwaters of the river are located in the Canaan Valley Resort State Park, south of the refuge. The river flows from the state park, north through the refuge. There are other small streams that contribute to wetland habitat on the refuge. In many cases, the refuge land encompasses the entire watershed of these small streams. However, there are several whose headwaters originate off-refuge. Sand Run and Yoakum Run are two tributaries to the Blackwater River that originate off-refuge, with headwaters on unprotected lands. Freeland Run originates on refuge land, but has a section that flows through an agricultural field before reentering the refuge.

5.2.5 Roads

The refuge maintains 31 miles of roads and trails (USFWS 2011, Figure 10). Not all of the old logging roads have been mapped on the refuge. Therefore, Figure 10 under represents the density of roads on the refuge. Roads can degrade aquatic habitat by increasing sedimentation, fragmenting habitat, and providing pathways for invasive species (Gucinski et al. 2000). At Canaan Valley, old logging roads are found throughout the refuge and are known to influence the natural movement of water across the landscape. In 2002 refuge staff completed an assessment of the hydrologic effects of selected refuge roads and trails on refuge water resources (USFWS 2002). The assessment noted that in many instances the roads are significantly impacting water resources by acting as dams or levees, channeling and/or diverting water or causing erosion and sedimentation problems. The assessment included recommendations to improve local hydrology such as replacing culverts, adding bridges, and plugging ditches (USFWS 2002). In 2004, the refuge implemented one of the recommendations from the memo and worked to add and replace culverts on A-Frame road. Additionally, the refuge had a Youth Conservation Corps (YCC) crew place sandbags in a ditch draining a wetland in the Beall Tract Barn Meadow (Ken Sturm personal communication). The status of the other recommendations in the memo is unknown.

5.2.5 Rail Grades

Railroad beds were constructed along almost every high elevation stream in the Canaan Valley during the logging boom of the late 19^{th} and early 20^{th} century (Figure 10). Rail grades fragmented wetland mosaics by creating multiple hydrologic barriers (Byers et al. 2007) that channelized streambeds and altered the hydrology of floodplain basins and their associated wetlands. Researchers at the USGS Leetown Science Center and Canaan Valley Institute (CVI) studied the affect of a historic rail grade on wetland hydrology in 2010 and 2011. The study focused on the central rail grade (see Figure 10) as it was thought to have the most severe impact on wetland hydrology. Although a final report has not been completed, the project investigators have summarized their results in a

Power Point presentation. Because of the orientation of the rail grade on the landscape, the study found that hydrology and vegetation patterns in the study area were more influenced by natural topographic gradients than by the rail grade itself, which only had localized influences (John Young, personal communication, Young et al. undated). The study found that the borrow ditch along the central rail grade is acting as a drain in a small section of the wetland. The study authors recommended encouraging beaver activity in the borrow ditch to offset these localized drainage effects (Young et al. undated).

Almost all rail grades and logging roads have the potential to drain wetland habitat because they have associated borrow ditches. Like the old logging roads, the old rail grades are not mapped completely (Figure 10) and the extent of the impacts on refuge wetlands remains uncertain.

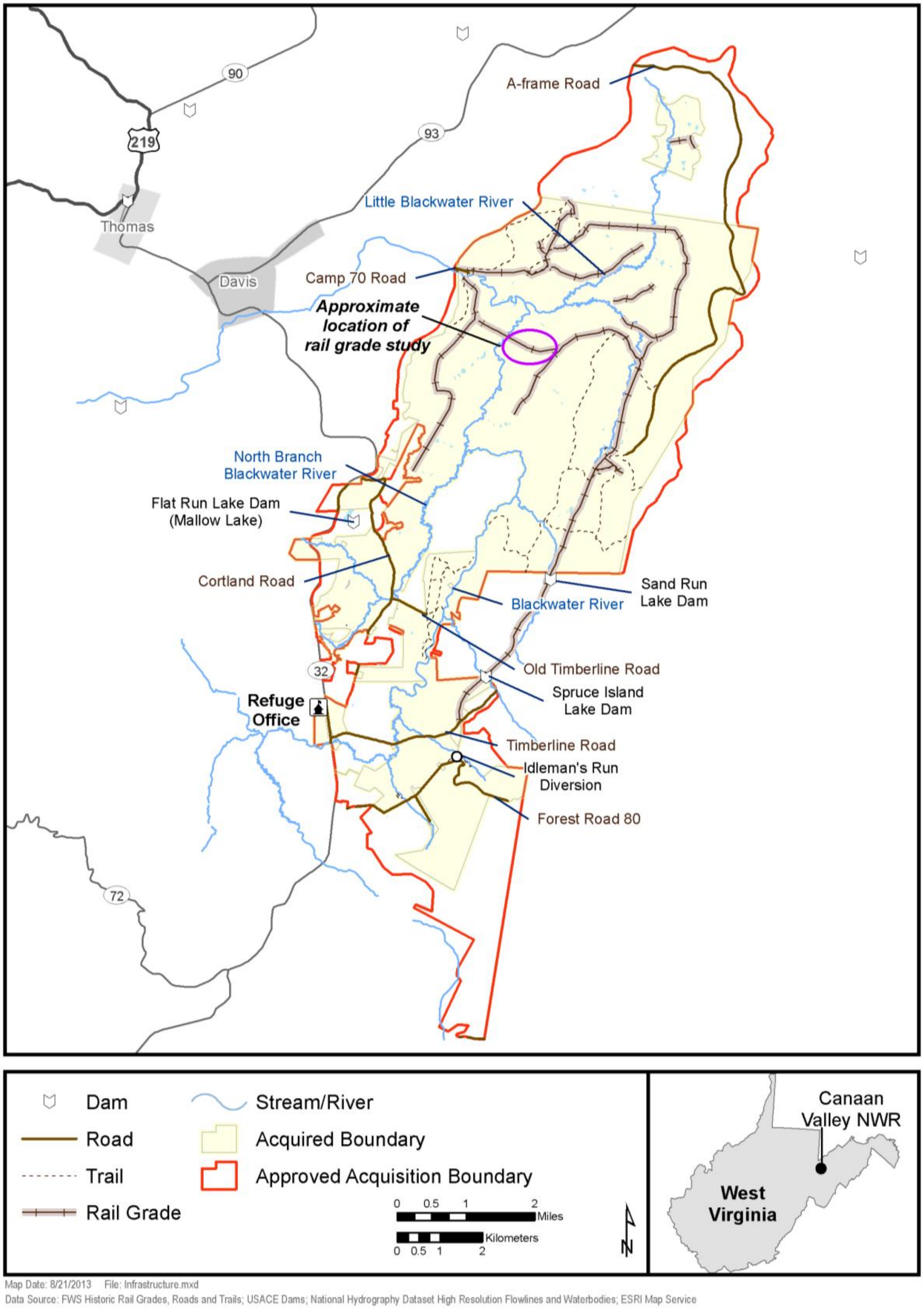


Figure 10. Infrastructure in the vicinity of Canaan Valley NWR.

5.3 Water Quality

Water quality information included in the WRIA is derived from the Reach Access Database (RAD) maintained by the U.S. Environmental Protection Agency (EPA). Additional data are publically available at the EPA's "Envirofacts" website. These databases were used to collect information on listed waters and National Pollutant Discharge Elimination System (NPDES) permits in and around the refuge.

5.3.1 Clean Water Act Impairments and TMDLs

Section 305(b) of the Clean Water Act requires that each state produce a comprehensive biennial report on the quality of the state's waters and Section 303(d) requires states to identify water bodies where water quality standards are not met. In West Virginia, WVDEP is responsible for generating an Integrated Water Quality Monitoring and Assessment Report (i.e., Integrated Report) of known water quality limited rivers and lakes to fulfill the requirements of section 305(b) and 303(d). In the Integrated Report, waters are given a designated use such as public water supply, aquatic life, or human health (WVDEP 2010). WVDEP and other agencies periodically sample water quality on the state's water bodies to determine if they meet the standards for designated uses. In the Integrated Report, waterbodies are placed in one of five categories that indicate the extent to which they meet designated uses (Table 6).

Table 6. List of Integrated Report categories (WVDEP 2010).

Category	Description
1	Fully supporting designated uses
2	Fully supporting some designated uses, but no or insufficient information exists to assess the other designated uses
3	Insufficient or no information exists to determine if any of the uses are being met
4	Waters that are impaired or threatened but do not need a TMDL
4a	Waters already have a TMDL but are not meeting standards
4b	Waters that have other control mechanisms in place which are reasonably expected to return the water to meeting designated uses
4c	Waters that have been determined to be impaired, but not by a pollutant
5	Waters that have been assessed as impaired and are expected to need a TMDL

Waterbodies that are considered impaired are then scheduled for development of a Total Maximum Daily Load (TMDL). TMDLs are documents prepared by EPA or WVDEP that define: 1) how much of a pollutant can go into the water each day without violating water quality standards and 2) distribute the total daily load to all significant point and non-point sources of the pollutant to the waterbody in question (USEPA 1998a).

The 2010 West Virginia Integrated Report identified 19.9 miles of impaired river and streams and 34.5 miles of assessed streams in the refuge acquisition boundary (WVDEP 2010) (Table 7, Figure 11). Impairments on the Blackwater River include aluminum, iron (both toxic to trout) and dissolved oxygen (DO). High iron, aluminum and pH levels are attributable to acid mine drainage from Abandoned Mine Lands and/or acid rain

(WVDEP 1996, Tetra Tech 2011). Freeland Run, a known brook trout fishery, is listed as biologically impaired because benthic macroinvertebrate populations are low (WVDEP 2010). The cause of impairment has not been identified; however, a tributary to Freeland Run receives discharge from a sewage treatment facility (Canaan Vistas), which was found to have a negative impact on the stream's macroinvertebrate populations (Butler 1987).

Table 7. Impaired waterbodies within the Canaan Valley NWR acquisition boundary (WVDEP 2010).

River Name	Listing Type	Cause	Miles within Acquisition Boundary	Miles on Refuge	Designated Use
Blackwater River	303d	Aluminum (trout)	15.4	10.6	Aquatic Life
Blackwater River	303d	Iron (trout)	15.4	15.4	Aquatic Life
Blackwater River	TMDL	DO	15.4	10.6	
Freeland Run	303d	CNA - Bio	1.2	0.8	Aquatic Life
Gandy Run	303d	pH	0.3	less than 0.1	Aquatic Life, Contact Recreation, Public Water Supply, All other uses

(Note: CNA = Conditions Not Allowable)

Low-gradient blackwater streams such as the Blackwater River have naturally low dissolved oxygen concentrations and pH due to high concentrations of dissolved and particulate organic matter (Chambers 1996). As a result, aquatic habitats in Canaan Valley may be particularly sensitive to anthropogenic activities that increase biological oxygen demand and acidity (Snyder et al. 2006). The EPA developed a DO TMDL for the Blackwater River in 1998. The TMDL was developed to help define the waste allocations from different wastewater treatment plants in the river's watershed. The TMDL report concluded that most of the impacts from wastewater treatment facilities are concentrated in the upper and middle reaches of the Blackwater River in the southern half of the valley. The section of the Blackwater River just upstream of where it exits the refuge has naturally low concentrations of DO due to the extensive wetland acreage and beaver dams in the watershed. The TMDL determined that the DO concentration in this lower reach was not affected by point discharges from wastewater treatment facilities upstream (USEPA 1998a).

5.3.2 NPDES Permits

NPDES permits are issued to businesses by WVDEP to regulate the quality and quantity of pollutants discharged into waters of the United States. Stormwater and treated wastewater are two examples of discharges regulated under the NPDES program. There are 14 NPDES permits for wastewater treatment facilities within or near the refuge acquisition boundary (Table 8, Figure 11). The Canaan Valley Public Service District

(PSD) is in the process of constructing new treatment facilities and phasing out some existing plants. Two new wastewater treatment plants have recently been constructed (Map IDs 3 and 7 in Table 8 and Figure 11) and two more are underway (Canaan Valley NWR staff, personal communication). The Black Bear Resort (Map ID 1) is listed as closed in the WVDEP database and may be one of the facilities being phased out.

Table 8. NPDES permits within or near Canaan Valley NWR acquisition boundary.

ID on Figure 12	Permit ID	Facility Name
1	WVG550641	BLACK BEAR RESORT
2	WVG550795	BEAVER RIDGE STP
2	WVG550887	NORTHPOINT/CANAAN MT. RESORT
3	WV0106011002	CANAAN VALLEY PSD
4	WV0105741001	HIGH MEADOW FARM LLP
5	WVG550715	DEERFIELD VILLAGE
6	WV0082775001	WINDWOOD RESORT
7	WV0106011001	CANAAN VALLEY PSD
8	WVG550918	CANAAN VALLEY NWR
9	WVG550794	CANAAN VILLAGE INN
10	WVG990163	CANAAN VALLEY NWR
11	WVG640078	CANAAN VALLEY STATE PK WTP
12	WVG550802	BLACKWATER CENTER
13	WVG550906	LOCHOA UTILITIES INC.

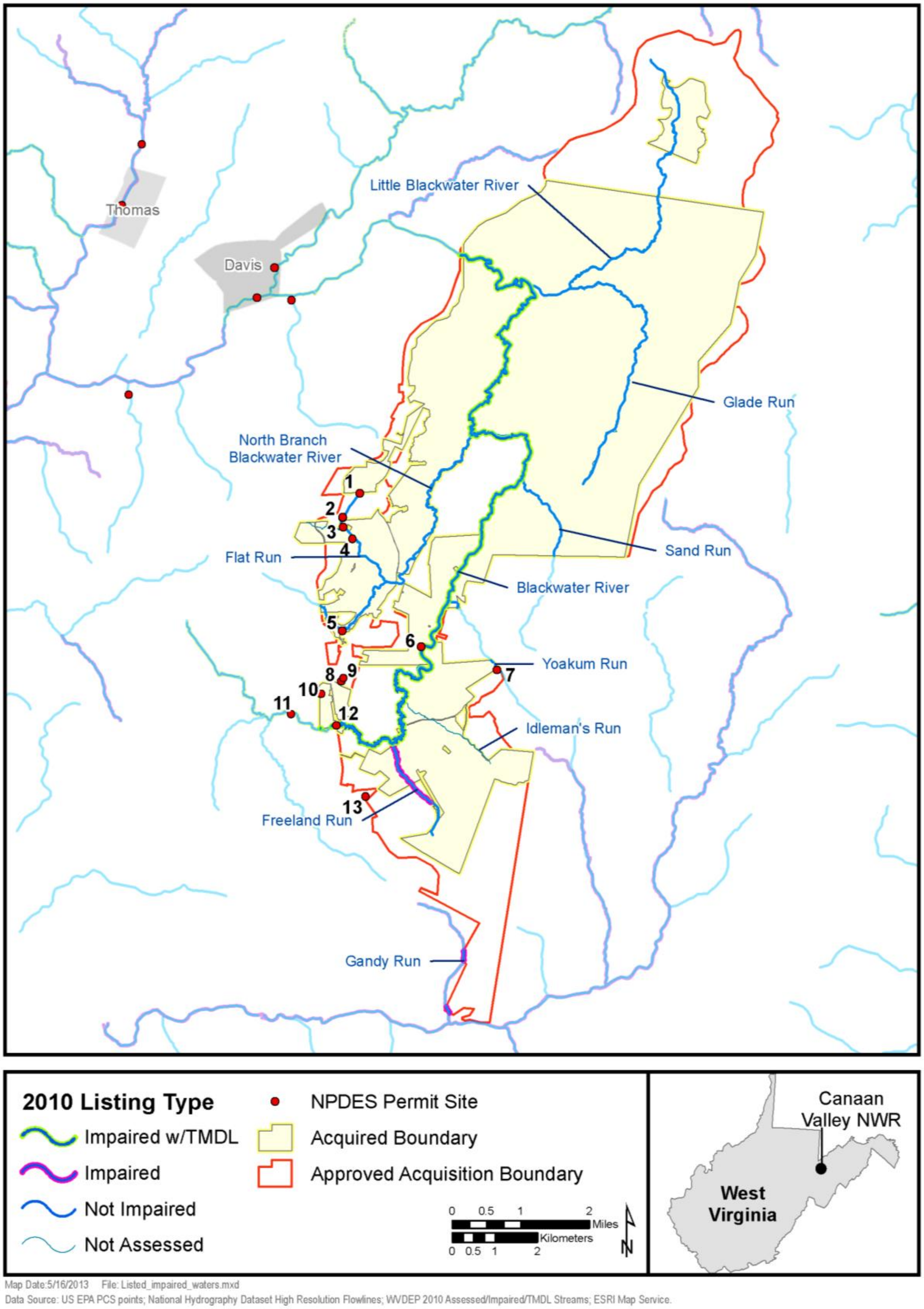


Figure 11. EPA listed waters and NPDES permit sites in and around Canaan Valley NWR.

5.3.3 Water Quality Reports

The findings of several reports evaluating the quality of surface water near Canaan Valley NWR are summarized in the paragraphs below:

- In 2011, a Contaminants Assessment Process (CAP) study was conducted to identify potential water quality concerns at the refuge. The study concluded that the primary contamination concern is the potential for spills and waste associated with current and future gas wells/pipelines and mines. Low levels of petroleum hydrocarbons and mercury have been detected down gradient of an active gas well on Tract 42. Additionally, brine produced by gas production may be contributing to dead vegetation near gas wells (Patnode 2011).

- The CAP report identifies atmospheric deposition of pollutants (including mercury) from industries and coal-fired power plants as a secondary contamination concern for the refuge (USFWS 2011, Patnode 2011). The report notes this concern stems from the refuge topography and elevation, observed acid precipitation and high potential for mercury methylation within the wetlands (Patnode 2011).

- In 1993, the USFWS monitored the effects of off-road vehicle racing on water quality and found those activities increased turbidity, suspended sediment concentrations and fecal bacteria concentrations (Chambers et al. 2002). The racing events have since ended, but off-road vehicle usage remains an issue for the refuge (Canaan Valley NWR staff, personal communication).

- A study of denitrification rates sought to determine the capability of the valley's wetlands to remove sewage-derived nutrients. The results of this work show that persistent-emergent wetlands have very large concentrations of denitrifying bacteria due to the dominance of macrophytes and the oxygenated layer around their roots (Chambers 1996).

- The USGS sampled 50 groundwater wells to characterize the water chemistry of the valley's bedrock aquifer. The constituents that commonly exceeded drinking water standards were fecal coliform and fecal streptococcus bacteria, radon, manganese and pH, with bacteria and radon being the most prevalent contaminants of concern (Chambers et al. 2002).

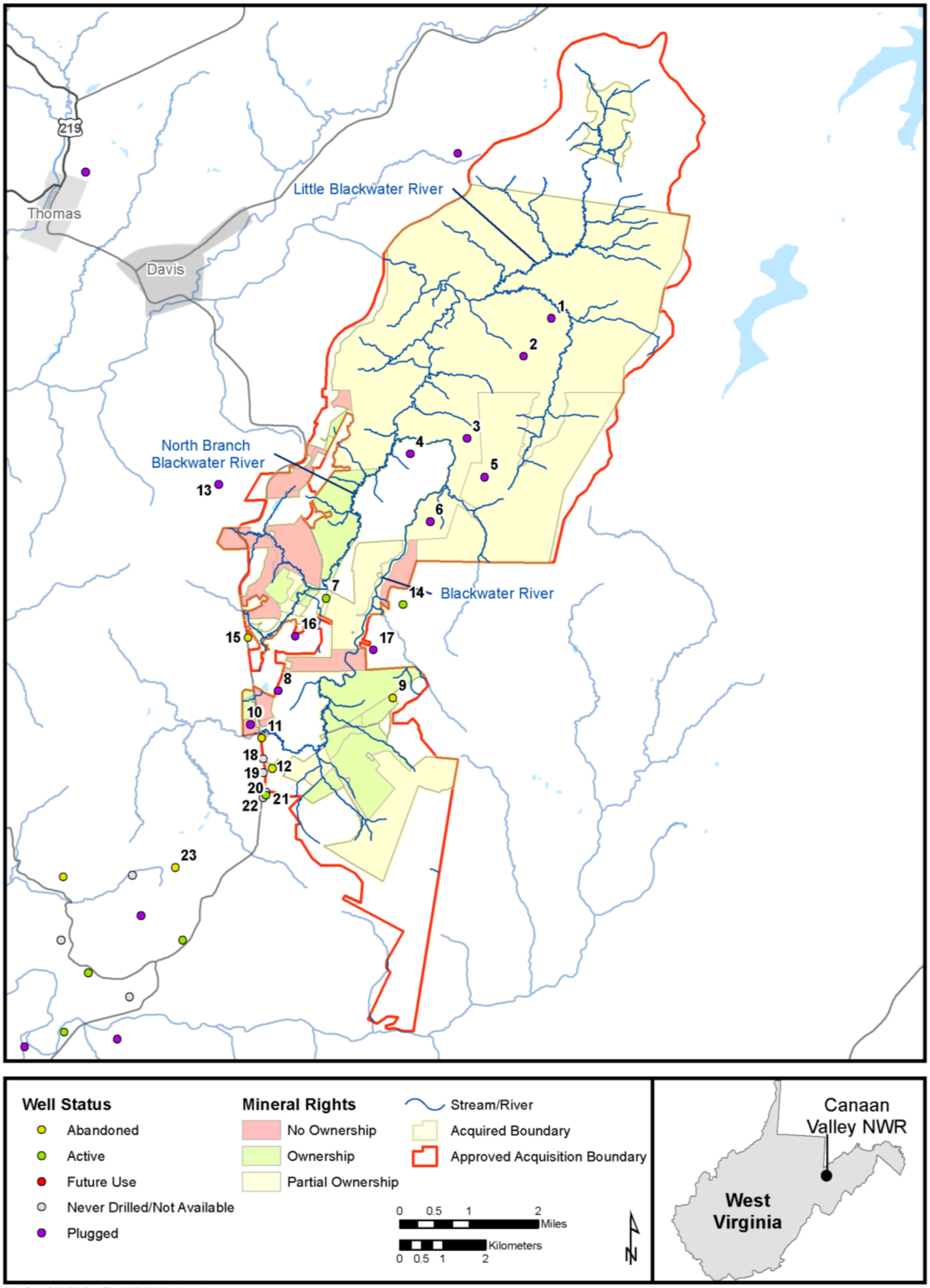
- In 1996 WVDEP conducted an Ecological Assessment of the Cheat River Watershed. Sites on the Blackwater River and several of its tributaries that enter the refuge were sampled for benthic macroinvertebrates. Sites on Sand Run and Glade Run were found to be impaired due to acid mine drainage, acid rain and/or sedimentation (WVDEP 1996).

5.3.3 Gas Wells

WVDEP Office of Oil and Gas is responsible for regulating and monitoring oil and gas exploration and drilling in West Virginia. The agency maintains a publically available database of oil and gas wells in West Virginia. The database is updated regularly and contains information on almost 55,000 wells. Well locations from the database are plotted in Figure 12 to determine if any active wells are located near Canaan Valley NWR.

Surface water quality can be impaired by activities associated with oil and gas well drilling. Modern techniques of hydraulic fracturing use large volumes of water to extract natural gas from shale deposits. Much of the water used to develop gas wells returns to the surface as "flowback" water and contains the chemicals used in the fracturing process and dissolved minerals from the shale formation. Once the well is in production, water returns to the surface with the gas. This "formation" water can be more saline than seawater and poses considerable threats to aquatic biota if accidentally spilled into streams or wetlands. Additionally, water withdrawals from streams to support gas development can significantly reduce streamflow in small brooks, particularly during the summer low flow period (Soeder and Kappel 2009).

Oil and natural gas wells in, or near, the refuge acquisition boundary are primarily located in the middle of the valley, where the relatively thin Greenbrier Limestone allows easiest access to the older Devonian strata below (Figure 3, Figure 12). There are 23 permits for oil and gas wells in the vicinity of the refuge; three are active and the rest are plugged, abandoned or were never drilled (Figure 12, Table 9). Of the active wells, one is within the refuge acquisition boundary (Map ID 7) and two are upstream of the refuge (Map IDs 14 and 21; Figure 12, Table 9).



Map Date:5/16/2012 File: NWI_Wetlands.mxd
Data Source: WVDEP Oil and Gas Wells; FWS Mineral Rights; National Hydrography Dataset High Resolution Flowlines; ESRI Map Service.

Figure 12. Oil and gas wells in the vicinity of Canaan Valley NWR and refuge mineral rights.

Table 9. Oil and gas wells in the vicinity of Canaan Valley NWR.

Map#	Permit ID	Responsible Party	Status	Location
1	9300028	OPERATOR UNKNOWN	Plugged	On Refuge
2	9300025	OPERATOR UNKNOWN	Plugged	On Refuge
3	9300003	OPERATOR UNKNOWN	Plugged	On Refuge
4	9300033	OPERATOR UNKNOWN	Plugged	In Acquisition Boundary
5	9300009	BLAHO OIL & GAS CO	Plugged	On Refuge
6	9300001	OPERATOR UNKNOWN	Plugged	On Refuge
7	9300065	BEALL, ROSCOE C. III	Active	In Acquisition Boundary
8	9300050	BEREA OIL & GAS CORP	Plugged	In Acquisition Boundary
9	9300055	BIG SAND DRILLING CO	Abandoned	In Acquisition Boundary
10	9300046	BEREA OIL & GAS CORP	Plugged	On Refuge
11	9300058	DRI OPERATING COMPANY	Abandoned	On Refuge
12	9300049	BIG SAND DRILLING CO	Abandoned	In Acquisition Boundary
13	9300064	BEREA OIL & GAS CORP	Plugged	Upstream
14	9300002	CHESAPEAKE APPALACHIA, L.L.C.	Active	Upstream
15	9300056	DRI OPERATING COMPANY	Abandoned	Upstream
16	9300060	BEREA OIL & GAS CORP	Plugged	Upstream
17	9300004	CONSOLIDATION COAL COMPANY	Plugged	Upstream
18	9300037	OPERATOR UNKNOWN	Never Drilled	Upstream
19	9300053	BEREA OIL & GAS CORP	Never Drilled	Upstream
20	9300052	BEREA OIL & GAS CORP	Never Drilled	Upstream
21	9300054	ENGLER, INC.	Active	Upstream
22	9300048	BEREA OIL & GAS CORP	Never Drilled	Upstream
23	9300035	ENGLER, INC.	Abandoned	Upstream

Other than the well locations, there is little information available on these wells. The primary threat to refuge water resources from these gas wells is if a spill occurs at the well site and contaminates waters entering the refuge. It appears that the existing wells have been in place for some time and are not using high volumes of water (> 80,000 gpm) to fracture the shale deposits containing gas. At present, it appears that refuge water resources are not being impacted by gas well drilling. However, risks remain and refuge staff should continue to monitor gas well activities in Canaan Valley. Monitoring equipment for tracking changes in hydraulic conductivity should be installed in select streams where the potential for gas well activity is high. These data can be used to establish baseline conditions in refuge streams prior to gas well construction.

5.3.4 Water Quality Overview

Because the refuge property includes the entire watershed of many refuge streams and development in Canaan Valley is somewhat limited, the water quality of refuge streams is generally good. The primary water quality concerns are related to residential and commercial development in the southern half of the valley, near Canaan Valley State Park and Timberline Four Seasons Resort. Additionally, stream water quality is threatened by erosion and sedimentation from past road construction and wastewater discharge.

The numerous roads and rail grades built for logging operations continue to cause sedimentation problems in refuge water resources. One example is the roads built for the failed development on Bearden Knob. Erosion and sedimentation are also concerns on the Freeland Tract. Freeland Run is unbuffered as it crosses an agricultural field and is delivering high sediment loads to a spring-fed pool on the refuge (Canaan Valley NWR staff, personal communication).

Low dissolved oxygen concentrations in the Blackwater River are attributed to wastewater treatment facilities, beaver dams, and wetlands. Wastewater treatment in the Canaan Valley is generally localized and private and includes extended aeration plants, aerated lagoons and individual septic tanks (USEPA 1998a). There are also unregulated settling ponds associated with septic systems at an unknown number of locations. The cumulative effect of these facilities appears to be limited to reaches of the Blackwater River (USEPA 1998a) and its tributaries in the southern half of the valley.

Residential and recreational development in the valley appears to be expanding and is expected to continue with completion of the Appalachian Corridor H project (U.S. Route 48). Construction of the Davis to Bismarck portion northwest of the refuge is currently underway and expected to be complete in 2015 (http://www.wvcorridorh.com/route/map4.html). Due to its location and drainage patterns, no direct hydrologic impacts to the refuge are anticipated, but it could lead to increased development in the valley which may place more demands on existing water resources and require more wastewater discharge into refuge streams.

5.4 Water Monitoring

WRIAs identify water-related monitoring that is taking place on, or near, wildlife refuges and fish hatcheries. For this preliminary review, the WRIA collects information stored in the USGS' NWIS database. Water monitoring can be broadly categorized as either water quality or water quantity focused. Water quality monitoring typically consists of collecting surface water or groundwater samples for chemical analyses in a laboratory or with sensors deployed in the field. Alternative protocols may use techniques such as aquatic invertebrate sampling as a proxy for water quality. Water quantity monitoring typically includes the flow rate in a stream, the water level in a groundwater aquifer, or water levels in refuge impoundments. WRIAs also consider weather stations and tide gages as other types of water-related monitoring.

5.4.1 Water Quantity Monitoring

This review identified 30 water quantity monitoring sites near the refuge, including stream gages, groundwater wells, and atmospheric sites (Table 10, Figure 13). The majority of these sites are maintained by the USGS and are no longer being actively monitored.

The USGS monitors stream discharge at locations on the Blackwater River downstream of the refuge: Blackwater River near Davis (Map ID 2) and Blackwater River at Davis (Map ID 3) (Table 10, Figure 13).

The USGS has also measured groundwater well levels (depth to water level, feet below land surface) at 24 wells within or near the refuge acquisition boundary (Table 10, Figure 13). Most of the wells were measured once in 1991, presumably as part of the study by Kozar (1996) (Table 10).

There are four atmospheric sites within or near the refuge acquisition boundary. The NOAA/NWS Cooperative Observer Program (COOP) monitored temperature and precipitation (including snowfall) at a site in Thomas, WV (Map ID 1) from 1931 – 1995, and continues to monitor temperature and precipitation at the Canaan Valley 2 site (Map ID 17). The National Interagency Fire Center has a Remote Automatic Weather Station (RAWS) at Bearden Knob (Map ID 4) that measures temperature and precipitation. Finally, NOAA, in concert with the Canaan Valley Institute, operates a National Atmospheric Deposition Program (NADP)/Atmospheric Integrated Research Monitoring Network (AIRMoN)/Mercury Deposition Network (MDN) site on the Beall Tract (Map ID 11) that measures wet and dry deposition and other air quality parameters.

Table 10. Water quantity monitoring within or near the Canaan Valley NWR acquisition boundary.

ID on Figure 13	Site Number	Site Name	Category	Agency	Sample History
1	468807	THOMAS, WV, US	ATM	NOAA/NWS	1931 - 1995
2	3065400	BLACKWATER RIVER NEAR DAVIS, WV	ST	USGS	1991 - 2013 (daily)
3	3066000	BLACKWATER RIVER AT DAVIS, WV	ST	USGS	1921 - 2013 (daily)
4	BDKW2	Bearden Knob RAWS	ATM	USFS/BLM	1996 - present
5	390605079254201	Tuc-0101	GW	USGS	1991 - 1994
6	390540079255001	Tuc-0095	GW	USGS	1991 (1 sample)
7	390419079265401	Tuc-0108	GW	USGS	1991 (1 sample)
8	390409079225201	Tuc-0078	GW	USGS	1991 (1 sample)
9	390356079270001	Tuc-0077	GW	USGS	1991 (1 sample)
10	390352079263801	Tuc-0107	GW	USGS	1991 (1 sample)
11	WV99	Beall Tract NADP	ATM	NOAA/CVI	2000 - present
12	390332079260401	Tuc-0074	GW	USGS	1991 (1 sample)
13	390334079253001	Tuc-0106	GW	USGS	1991 (1 sample)
14	390328079225901	Tuc-0086	GW	USGS	1991 (1 sample)
15	390316079261201	Tuc-0105	GW	USGS	1991 (1 sample)
16	390313079245301	Tuc-0057	GW	USGS	1991 (1 sample)
17	461397	CANAAN VALLEY 2	ATM	NOAA/NWS	1993 - present
18	390254079265001	Tuc-0103	GW	USGS	1991 (1 sample)
19	390255079264401	Tuc-0104	GW	USGS	1991 (1 sample)
20	390251079263001	Tuc-0073	GW	USGS	1991 (1 sample)
21	390236079264701	Tuc-0072	GW	USGS	1991 (1 sample)
22	390231079235501	Tuc-0081	GW	USGS	1991 (1 sample)
23	390217079272201	Tuc-0125	GW	USGS	2011 (1 sample)
24	390218079263801	Tuc-0071	GW	USGS	1991 (1 sample)
25	390201079263601	Tuc-0070	GW	USGS	1991 (1 sample)
26	390121079274901	Tuc-0079	GW	USGS	1991 - 1993
27	390122079264301	Tuc-0080	GW	USGS	1991 - 1993
28	390121079263701	Tuc-0066	GW	USGS	1991 (1 sample)
29	390119079255601	Tuc-0065	GW	USGS	1991 (1 sample)
30	390103079264101	Tuc-0118	GW	USGS	1991 (1 sample)

(Note: ATM = Atmosphere, ST = Stream, GW = Groundwater, NWS = National Weather Service, USFS = U.S. Forest Service, BLM = Bureau of Land Management)

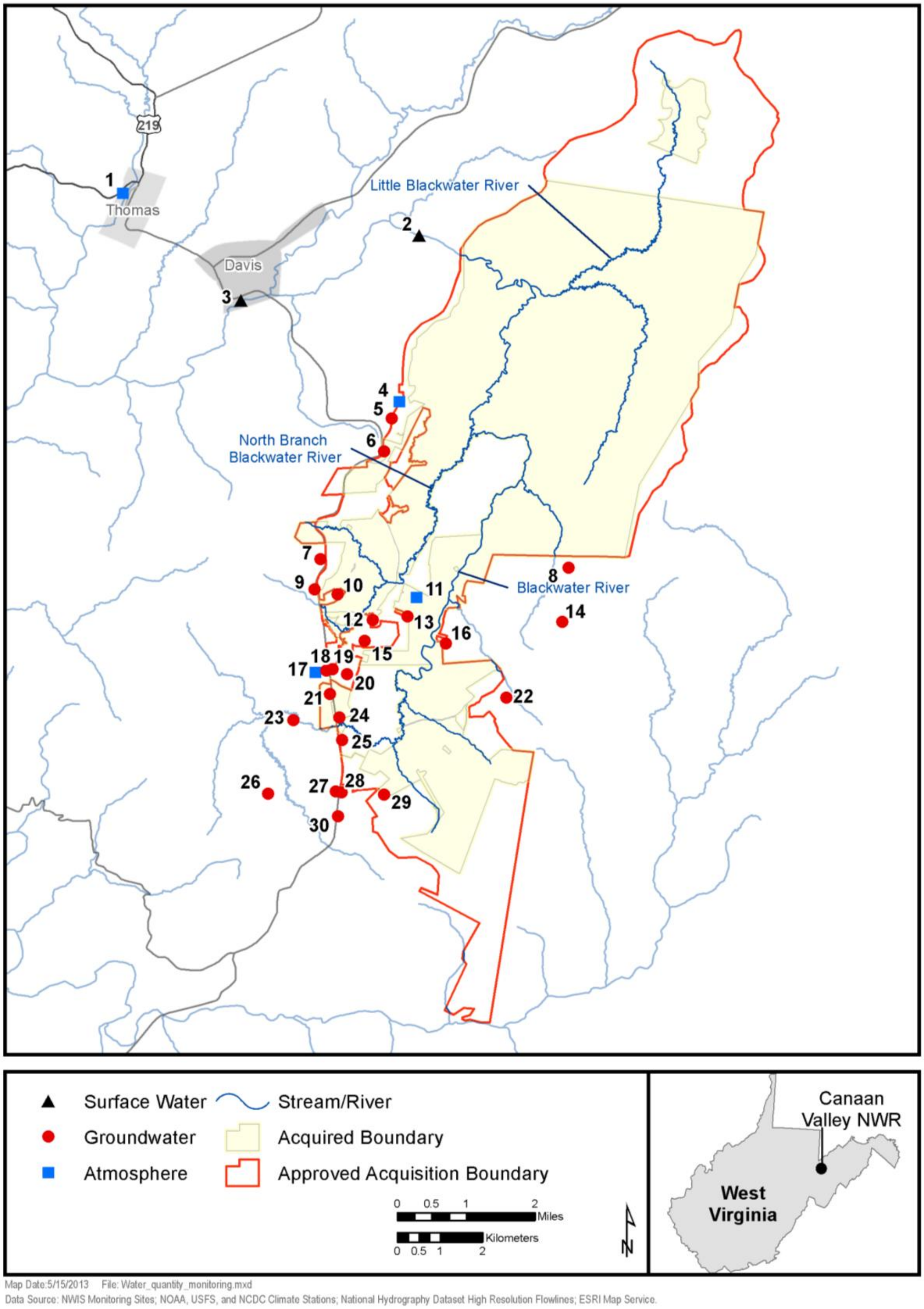


Figure 13. Water quantity monitoring within or near the Canaan Valley NWR acquisition boundary.

5.4.2 Water Quality Monitoring

The USGS NWIS database identifies 22 active surface water, groundwater and spring water quality monitoring sites within the refuge acquisition boundary that have been sampled at least three times (Table 11, Figure 14). Many of these sites were sampled only three times between 1990 and 1993.

The U.S. Forest Service (USFS) monitors stream temperature using Hobo temperature probes at one site on the Blackwater River (Map ID 13 in Figure 14). In addition USFS collected a grab sample for water chemistry and are in the process of delineating watersheds above the monitoring site (Andy Dolloff, USFS, personal communication).

The WVDEP's Watershed Assessment Branch has conducted water quality monitoring of the Blackwater River and its tributaries within the refuge acquisition boundary as recently as 2009. WVDEP has collected data at a variety of locations on the refuge over the years but these are typically not re-visited annually. Data may be collected to support baseline surveys, TMDL development, and/or Watershed Assessment Program projects (WVDEP 2010). The locations of sites where WVDEP has collected water quality data in the past are identified in Figure 14, but only sites that are regularly measured are numbered and listed in Table 11. The parameters measured depend on the survey type. The most comprehensive sampling is done to support probabilistic (random) sampling designed to characterize water quality conditions in the state's watersheds. These surveys include water chemistry, habitat, stressor observations, benthic macroinvertebrates, fecal coliform and some fish sampling (WVDEP 2010). Targeted sites in the Blackwater River will be monitored next in 2016 (Jeff Bailey, WVDEP, personal communication).

WVDEP, in coordination with the USGS, also maintained an Ambient Groundwater Quality Monitoring Network from 1999 to 2008 that consisted of public supply wells, USGS monitoring wells and springs. The only site in the network within Tucker County is Sand Spring (on Sand Run) (Kozar and Brown 1995, Map ID 16 in Figure 14).

Table 11. Water quality monitoring within or near the Canaan Valley NWR acquisition boundary. Includes sites with at least three samples.

ID on Figure 14	Site Number	Site Name	Type	Agency	Sample History (# of samples)
1	3065400	BLACKWATER RIVER NEAR DAVIS, WV	ST	USGS	1990 - 1993 (26)
2	3066000	BLACKWATER RIVER AT DAVIS, WV	ST	USGS	1945-1993 (325)
3	390740079271801	BLACKWATER RIVER ABOVE MOUTH BEAVER CREEK	ST	USGS	1993 (12)
4	390742079232401	C21 BLACKWATER RIVER ABOVE LIT. BLKWTR RIVER	ST	USGS	1991-1992 (3)
5	390744079232201	C22 LITTLE BLACKWATER RIVER @ MOUTH	ST	USGS	1991 - 1993 (9)
6	390552079242201	C17 BLACKWATER RIVER ABOVE NORTH BRANCH	ST	USGS	1991 - 1993 (14)
7	390548079242601	C20 NORTH BRANCH @ MOUTH	ST	USGS	1991 - 1993 (14)
8	390534079254401	Tuc-0061	GW	USGS	1990 - 1991 (5)
9	390516079233801	C15 BLACKWATER RIVER ABOVE SAND RUN	ST	USGS	1991-1992 (3)
10	390515079233401	C 16 SAND RUN @ MOUTH	ST	USGS	1991-1992 (3)
11	WV0106011002	CANAAN VALLEY PSD	OF	WVDEP	
12	390400079253301	NORTH BRANCH AT CORTLAND, WV	ST	USGS	1990 - 1992 (17)
13	8199	USFS/Virginia Tech Site	ST	USFS	2010 - present
14	390344079245001	C10 BLACKWATER RIVER ABOVE YOAKUM RUN	ST	USGS	1991-1992 (3)
15	390346079244801	YOAKUM RUN AT MOUTH	ST	USGS	1990 - 1992 (16)
16	390324079232501	Tuc-0085(Sand Spring) (Inactive)	SP	USGS	1991 - 2010 (5)
17	390328079262501	C18 NORTH BRANCH HEADWATER	ST	USGS	1991-1992 (3)
18	WV0106011001	CANAAN VALLEY PSD	OF	WVDEP	2011 - present
19	390215079274701	C2 MILL RUN @ MOUTH	ST	USGS	1991-1992 (3)
20	390221079274101	C4 BLACKWATER RIVER BELOW CLUB RUN	ST	USGS	1991-1992 (3)
21	390217079272201	Tuc-0125	GW	USGS	2002 - 2011 (3)
22	390215079271401	C6 BLACKWATER RIVER BELOW D5	ST	USGS	1991-1992 (3)
23	390211079253601	BLACKWATER RIVER ON TIMBERLINE ROAD	ST	USGS	1990 - 1992 (17)
24	390158079254801	C7 BLACKWATER RIVER ABOVE FREELAND RUN	ST	USGS	1991-1992 (3)
25	390156079254701	C8 FREELAND RUN @ MOUTH	ST	USGS	1991-1992 (3)
26	390136079273301	MILL RUN AT CANAAN VALLEY STATE PARK, WV	ST	USGS	1990 - 1992 (17)

(Note: ST = Stream, GW = Groundwater, OF = Outfall, SP = Spring)

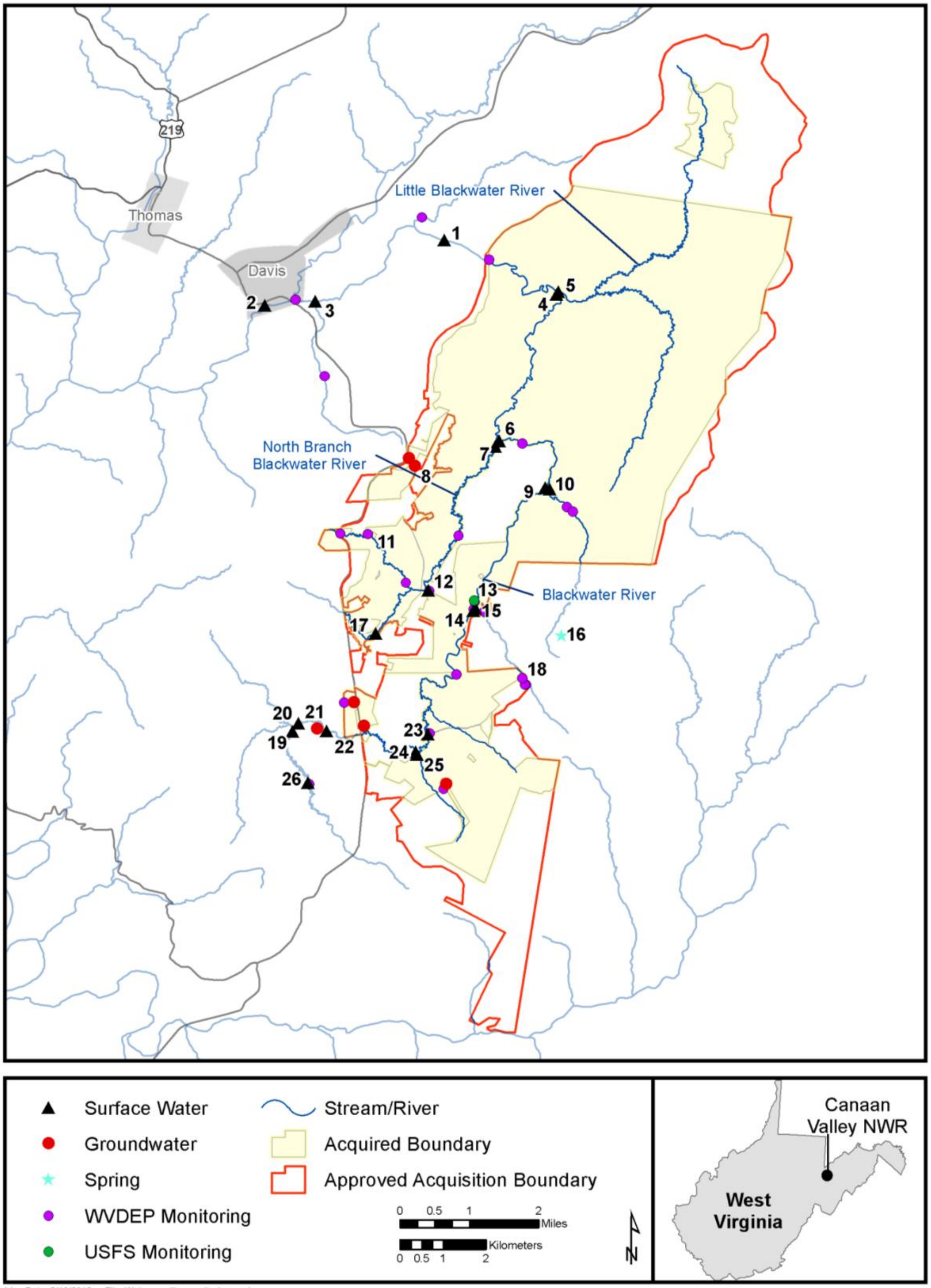


Figure 14. Water quality monitoring within or near the Canaan Valley NWR acquisition boundary.

5.4.3 Water Monitoring Data Gaps

Most of the water monitoring identified in Section 5.4 represents sampling that was done by the USGS in the 1990s, most likely to support studies like the report by Kozar (1996) and Kozar and Brown (1995). Although WVDEP periodically monitors water quality conditions at sites on the refuge, these data are collected sporadically during state-wide data collection efforts. In general there appears to be little active water quality and water quantity monitoring other than at a few locations on the Blackwater River downstream of the refuge.

Although the quality of refuge waters is generally good, questions remain over the potential impacts to refuge water resources from increasing development in the southern half of the valley. Groundwater and surface water diversions for drinking water and snowmaking have the potential to de-water small streams during the summer months. Increased development within Canaan Valley State Park and Timberline Four Seasons Resort may increase the sedimentation and nutrient loads to streams entering the refuge. An additional concern is the expansion of hydraulic fracturing activities into the Canaan Valley. In 2012, the Service purchased equipment to continuously monitor conductivity at 4 locations in refuge streams. These sensors are intended to quantify baseline conditions in streams where there are concerns about future gas well development and sewage discharge from wastewater treatment plants.

There is no flow monitoring in the Blackwater River on the refuge or upstream of the refuge. Therefore it is not possible to determine if surface water and groundwater diversions for recreational and commercial development are affecting streamflow on the refuge. Due to abundant precipitation, it seems unlikely that the current diversions are having a significant impact on Blackwater River flow. However, it is possible that during severe drought conditions or in the winter months, when snow making operations are at their peak, flow rates in the Blackwater could be reduced by surface water diversions. The impact of surface water diversions will be more acute on small tributary streams, like Idleman's Run, and diversions may lead to sections of those streams drying completely during droughts or winter low flows. The Service is not in a position to begin surface water flow monitoring on steams in Canaan Valley but may want to consider it to evaluate the potential impacts of surface water and groundwater use on streams entering the refuge from the south.

Due to its remote location and relatively large protected area, Canaan Valley NWR is a good location to consider additional water monitoring to support the Service's Inventory and Monitoring effort. Groundwater monitoring in refuge wetlands or streamflow monitoring on Glade Run offer the possibility of monitoring hydrologic conditions in relatively undisturbed areas of Region 5.

5.5 Water Rights

Water Law in West Virginia was recently summarized by the DOI solicitor's office (SOL 2013). The document provides an in-depth review of the legal framework governing water use in West Virginia. The summary of West Virginia water law in the Solicitor's memo is included below:

West Virginia currently maintains a traditional common law riparian approach to water rights, largely due to its geographic location, abundant water resources, and moderate population growth. Consequently, West Virginia relies primarily on the reasonable use doctrine to govern water rights. West Virginia's reasonable use doctrine states that a riparian landowner is entitled to make "reasonable use of any natural flow of water on his land, but any use of the water elsewhere by a diversion of the water, without returning it to the stream for the use of lower proprietors, is wrongful." This interpretation of the doctrine applies to surface water and underground streams. The reasonable use doctrine for percolating waters, however, allows a landowner to extract as much groundwater as is reasonable required for the beneficial use of the property, regardless of adverse impacts on neighboring users. Under common law, the courts have declined to clearly define reasonable and beneficial uses, and instead decide to determine "reasonableness" in the light of the facts and circumstances appearing in each case, as it arises.
At present, West Virginia has an extremely limited statutory and regulatory framework governing water rights. The West Virginia Legislature (Legislature) enacted the Water Resources Protection and Management Act (WRPMA) in 2004. The WRPMA orders the Department of Environmental Protection (WVDEP) to conduct a survey of large quantity water users (users in excess of 750,000 gallons per month), create a water use registration program, submit annual reports to the Legislature, and, ultimately, develop a comprehensive State Water Resources Management Plan. The WVDEP must submit its proposal for a State Water Resources Management Plan to the Legislature by November 13, 2013.

In addition to the WRPMA, there are several other statutes that affect water rights in West Virginia. The Groundwater Protection Act (GPA) protects West Virginia's groundwater resources, by granting the WVDEP Secretary the authority to promulgate standards of purity and quality for groundwater and to establish maximum contaminant levels for groundwater (not to exceed federal standards). The Water Pollution Control Act (WPCA) makes it illegal for any person ("person" expressly includes governmental agencies, including federal facilities) to allow any waste or pollutants to flow into the waters of the state without a permit from the WVDEP. In turn, the Secretary may issue a permit for the disposal of pollutants into the water, after notice and public hearing, as long as it complies with applicable federal water standards. Permits are not valid for more than five (5) years. The Natural Stream Preservation Act (NSPA) emphasizes the importance of protecting the benefits of free-flowing streams; these benefits include fish and wildlife. Under this statute, persons, including governmental agencies, must apply to the WVDEP for a permit if they wish to modify any part of a "protected stream."

In the event of a water emergency, which includes water shortages and droughts, West Virginia's Division of Homeland Security and Emergency Management statute gives the Governor and state executives broad powers to address and prevent disasters.

Lastly, it is important to note that while federal agencies are generally exempt from state regulatory programs unless there is an express waiver of sovereign immunity, the National Wildlife Refuge Administration Act has expressly waived sovereign immunity for the FWS and thus it must comply with state water rights allocation programs. We have only provided this very brief mention of matters of sovereign immunity as this memo focuses on the regulatory and allocation process within West Virginia for water users. The Service should discuss any matters concerning state licensing processes and waiver of sovereign immunity with the Regional Solicitor's Office.

West Virginia DEP has registered two large quantity users in the Canaan Valley: Canaan Valley State Park and Timberline Four Seasons Resort. Water is being used to provide public water supply at the facilities. Both users rely on groundwater wells and Canaan Valley State Park also diverts surface water from the Blackwater River. In addition to registering large water users, WVDEP requires permits for pumping or diverting water for hydraulic fracturing activities. It is not known if any surface water or groundwater is being pumped from Canaan Valley for hydraulic fracturing operations.

Water Use regulations in West Virginia are liable to change after 2013 when WVDEP finishes its Water Resources Management Plan.

5.5.1 Water Use Conflicts

West Virginia does not have a defined process for resolving water use conflicts. At present it appears conflicts will be resolved in court on a case-by-case basis. Thus, injured parties will need to make a legal case that they are being harmed by another water user. Cases of this type can be very contentious and often hinge on quantification of water use, which requires robust water quantity data collection practices.

5.6 Climate Trends

A variety of datasets exist that can be used to evaluate long-term climate trends at refuges in Region 5. Some of these data are included in the WRIA to provide a preliminary analysis of trends in precipitation, temperature, and stream runoff. Data were analyzed for trends using the nonparametric Mann-Kendall statistical test. This test can be used to determine if there is a linear trend in a dataset and whether or not that trend is statistically significant ($p < 0.05$) (Helsel and Hirsch 2002).

5.6.1 U.S. Historical Climatology Network (USHCN)

The USHCN is a network of climate monitoring sites maintained by the National Weather Service. Sites in the network are selected because their location and data quality make them well suited for evaluating long-term trends in regional climate. The closest site to the refuge is located in Parsons, WV. Data from the site illustrate trends in precipitation and air temperature in the Canaan Valley area over the last 115 years (Figures 15 – 17) (Menne et al. 2011).

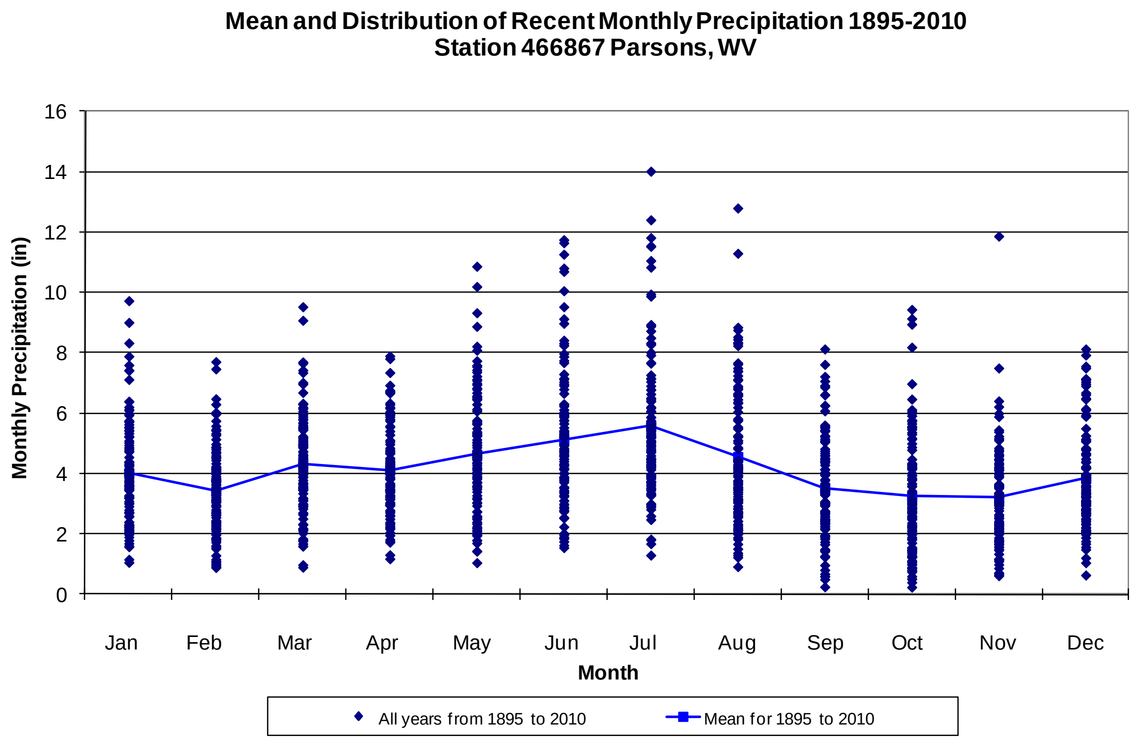
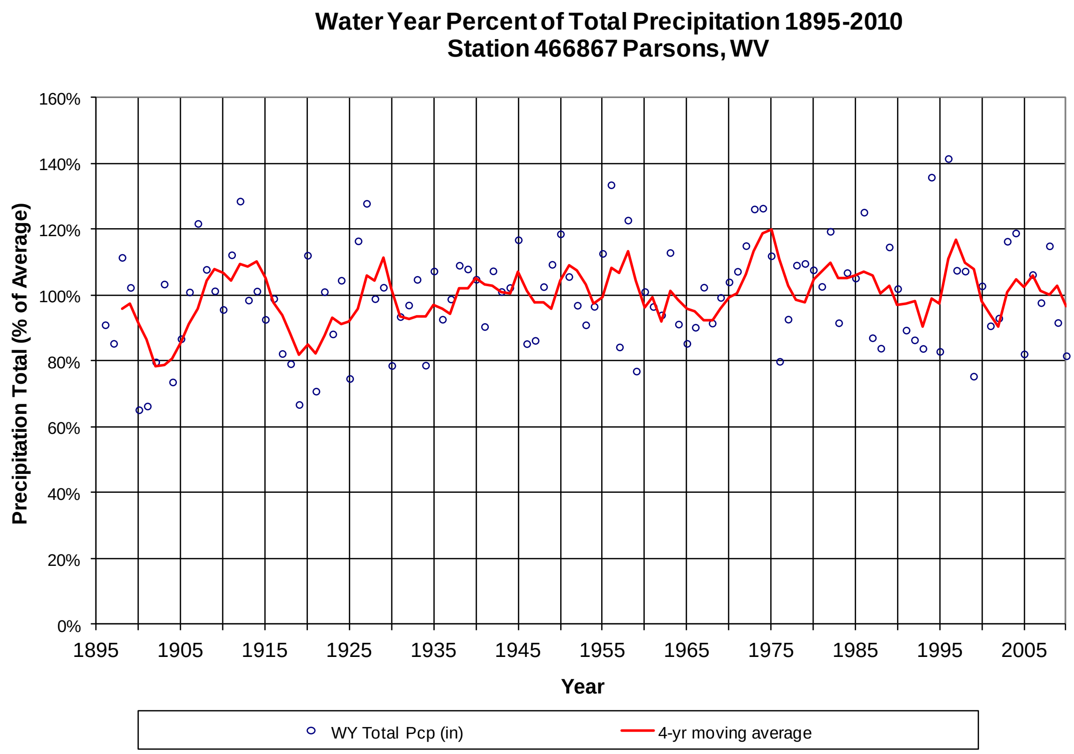


Figure 15. Mean and distribution of total monthly precipitation at USHCN Station 466867 in Parsons, WV: 1895-2010.

Trends presented in Figure 15:

- Higher precipitation in spring and summer (May through August) than during fall and winter.
- Average monthly precipitation is 4.1 inches.
- Average water year precipitation is 49.6 inches.

Precipitation patterns were evaluated by calculating the difference between each year's average precipitation and the average for all years. Presented as a percent, this approach can be used to identify years of above average, or below average, precipitation (Figure 16).



Note: "Water Year" runs from October 1 through September 31. It is commonly used to track hydrologic data.

Figure 16. Percent of total Water Year precipitation at the Parsons, WV USHCN site between 1895 and 2010.

Trends presented in Figure 16:

- Data suggest the mid-1970s was a period with above average precipitation.

- The mid-1960s appears to be a period of below average precipitation. The Central Climate Division of West Virginia, in which the refuge is located, underwent a 13-month drought from 1965 to 1966 (http://www.nrcc.cornell.edu/drought/WV_drought_periods.html).

Monthly temperatures at the Parsons, WV USHCN site were also reviewed to identify any patterns in air temperature since 1895 (Figure 17).

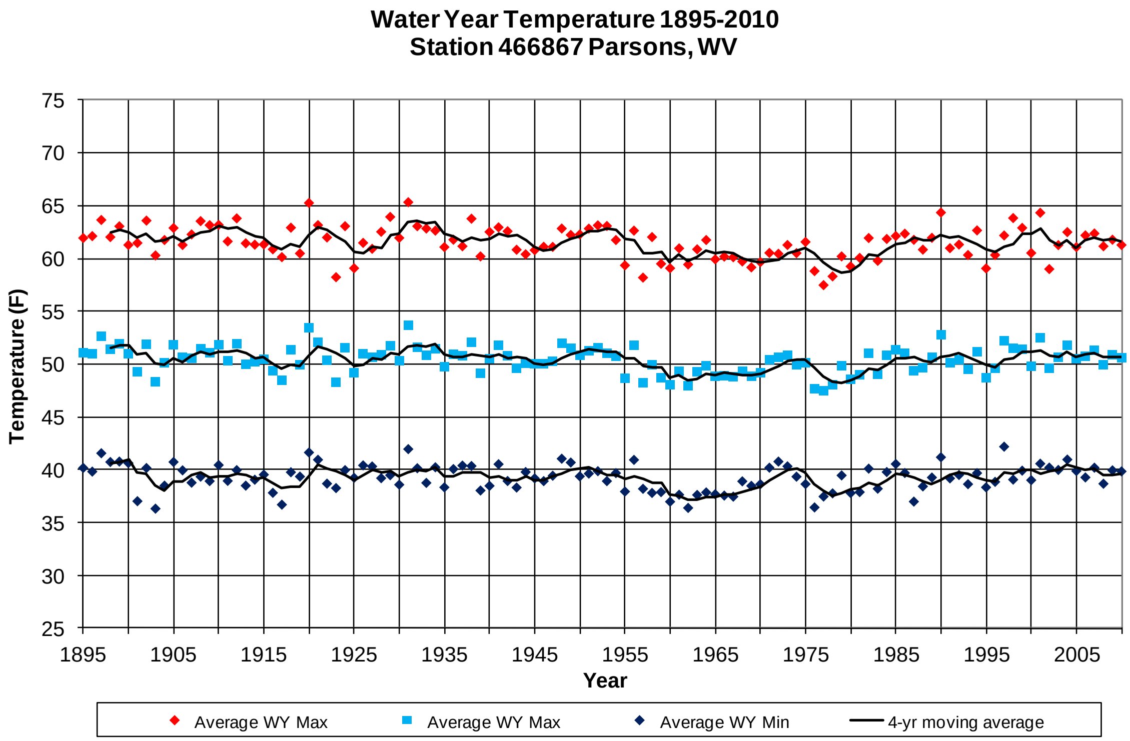


Figure 17. Average temperatures for the Water Year: 1895-2010 at the USHCN station in Parsons, WV. The Water Year extends from 10/1 – 9/30 of a year.

Trends presented in Figure 17:

- Average water year maximum temperature has decreased approximately 1.4 ^{o}F over the period of record (1896-2011). This is a statistically significant trend.
- Average water year mean temperature has decreased approximately 0.8 ^{o}F over the period of record. This is a statistically significant trend.
- Average water year minimum temperature has not changed significantly over the period of record.

The pattern of cooling temperatures identified in the Parson, WV USHCN data is contrary to the conventional wisdom of warming temperatures due to global climate change. The CCP cites an Intergovernmental Panel on Climate Change (IPCC) prediction stating that increases in average annual air temperature may eliminate a large percentage of brook trout habitat in the southern Appalachian Mountains (USFWS 2011). An EPA publication titled "Climate Change and West Virginia" cites an IPCC-predicted increase of 3°F in winter, spring and summer (with a range of 1-6°F) and a 4°F increase in fall (with a range of 2-7°F) (EPA 1998b). Other studies have reported increasing temperatures in the Canaan Valley and Appalachian region in general (Vogel and Leffler

2002, USFWS 2011). However, Pitchford et al. (2012) documented decreasing temperatures at high elevation sites in the mid-Atlantic. Figure 17 and the Pitchford (2012) study suggest climate change patterns at high elevation sites like the Canaan Valley remain uncertain and additional information is needed to determine if the trends observed elsewhere apply to these sites.

5.6.2 USGS Hydro-Climatic Data Network (HCDN)

The HCDN is a network of U.S. Geological Survey (USGS) stream gaging stations that are considered well suited for evaluating trends in stream flow conditions (Slack et al. 1992). Sites in the network have periods of record that exceed 20 years and are located in watersheds that are relatively undisturbed by surface water diversions, urban development, or dams.

The closest HCDN stream flow gage near the refuge is located on the Cheat River near Parsons, WV. The station has a period of record from 1913 to 2010. However, the stream gage on the Blackwater at Davis, has a similarly long record (1921-present). Because the Blackwater River gage is closer to the refuge we used its data to evaluate long-term flow patterns in streams near Canaan Valley.

Flow patterns were evaluated by calculating each year's average discharge difference from the average for all years. Presented as a percent, this approach can be used to identify years of above average or below average runoff (Figure 18).

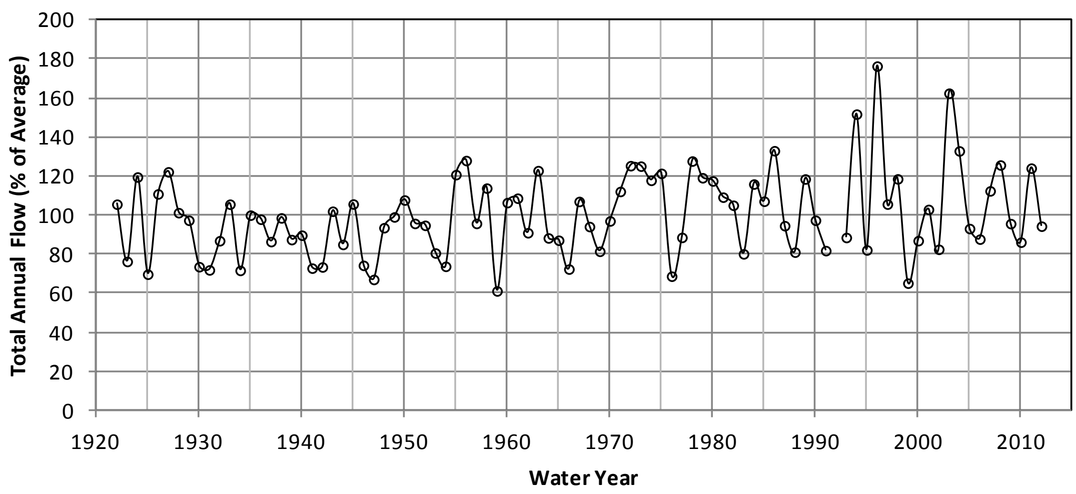


Figure 18. Percent of the average annual flow on the Blackwater River at Davis: 1922 - 2012.

Trends presented in Figure 18:

- The average annual flow from the period of record is 205 cfs.
- The highest average annual flow was in 1996 (362 cfs).

- The lowest average annual flow was in 1959 (125 cfs).

- Average annual streamflow in the Blackwater at Davis has increased approximately 37 cfs over the period of record. This increase is a statistically significant trend.

The long-term record presented in Figure 18 is expected to reflect runoff conditions in other watersheds on, and near, Canaan Valley NWR. Streamflow patterns in the Blackwater River at Davis roughly correspond to precipitation data presented in Figure 17. The increasing trend in average annual runoff could be a product of an increase in precipitation totals, land use changes in the Blackwater's watershed, or both.

5.6.3 Future Climate Predictions

The Intergovernmental Panel on Climate Change (IPCC) predicts the U.S. Northeast will experience earlier spring snowmelt and reduced summer runoff as the global climate warms in response to human emissions of greenhouse gasses (Bates et al. 2008, Mack 2008). Hayhoe et al. (2007) review historic climate data and climate change models to evaluate the Northeast's response to global climate change. Results of their analyses are summarized below:

> ***Temperature***
>
> Air temperature records in the Northeast show consistent signs of warming since the 1970s with the greatest increases occurring during the winter months. Warming trends are expected to continue and rates of warming increase under different climate modeling scenarios. As temperatures warm the frequency of extreme warm temperatures will increase also.
>
> ***Precipitation***
>
> Precipitation records in the Northeast show a consistent increase in annual precipitation totals over the last century. Under different climate modeling scenarios, winter precipitation is expected to increase while summer precipitation is expected to remain unchanged or decrease. In addition to annual increases, heavy, intense precipitation events are expected to become more common.
>
> ***Snowpack***
>
> The amount of snow cover has decreased across the Northeast in the last 30 years. This trend is expected to continue with less precipitation falling as snow in the winter months.

Streamflow Patterns

Since 1970, peak snowmelt runoff has occurred earlier in the year and the peak runoff values have been rising in winter and early spring. These patterns are expected to continue as wetter winters and warmer temperatures decrease winter snowpacks. The response to seasonal snowmelt will become less pronounced as more winter precipitation falls as rain. Peak flows are expected to be concentrated in the winter and early spring months and minimum streamflow will continue to be concentrated in the summer months. Minimum flows will be lower than the recent past and the duration of the summer low flow period is expected to increase.

Drought

Modeling scenarios predict that the frequency of severe, persistent drought (> 6 months) will remain at rates observed in the recent past. However, hotter drier summers and periodic precipitation deficits are expected to increase the frequency of short- (1-3 month) and medium-term (3-6 month) droughts. Periods of drought will be most pronounced at the end of the growing season in the late summer and early fall.

The climate data near Canaan Valley are somewhat different from the patterns described by Hayhoe et al. (2007). The pattern of cooling temperatures is particularly interesting because it is opposite to the prevailing trend of increasing temperatures in the Northeast. Pitchford et al. (2012) note that cooling trends are confined to high elevation areas of the mid-Atlantic. Near the coasts, climate station data shows a clear increasing trend in temperatures. Trends showing increasing temperatures are more widespread and the global climate models may not pick up local temperature trends like those found in mid-Atlantic highlands (Pitchford et al. 2012).

Management implications of climate change at Canaan Valley are related to the increase in total precipitation and the frequency of intense precipitation events. Pitchford et al. (2012) show that intense precipitation events are becoming more common in mid-Atlantic highlands like Canaan Valley. Additionally, precipitation is estimated to increase by 20% (with a range of 10-30%) in all seasons, slightly more in summer (EPA 1998b). The refuge used The Nature Conservancy's Climate Wizard program to model West Virginia temperature and precipitation changes by 2050 and found that average precipitation was predicted to increase by 10 percent, with most change occurring between December and May (USFWS 2011). These patterns have the potential to increase the frequency of flooding on the refuge. Due to the large number of roads and old rail grades on the refuge it is likely that more frequent precipitation events will lead to more erosion and sedimentation and infrastructure failures. The refuge may need to evaluate culvert sizes and road crossings at several locations in the future to ensure they can adequately pass runoff volume from more frequent storms.

6 ASSESSMENT

6.1 Water Resource Issues of Concern

This section discusses some of the challenges the refuge's water resources face. For the purposes of this initial review the primary water resources of interest are the wetland systems that are within the boundaries of the refuge.

6.1.1 Impacts of Old Logging Roads and Rail Grades

The impacts of forest roads have been studied and summarized in a U.S. Forest Service report: *Forest Roads: A Synthesis of Scientific Information* (Gucinski et al. 2000). Habitat fragmentation, sedimentation, erosion, and modification of natural runoff patterns are negative byproducts of road construction (Gucinski et al. 2000). Although written for National Forest managers, the findings in the report are applicable to the old logging roads and rail grades at Canaan Valley NWR. Refuge staff have evaluated the effects of roads on refuge wetlands (USFWS 2002) and the Service has funded studies to quantify the hydrologic impacts of old roads (Canaan Valley Rail Grade study 2010-2011). Although the 2010-2011 USGS study found that one rail grade had relatively minor impacts, there has yet to be a refuge-wide assessment of refuge roads and their affect on aquatic habitat.

6.1.2 Residential and Commercial Development in Southern End of Valley

Residential and commercial development in the southern end of the valley poses another obvious threat to refuge water resources. Surface water and groundwater diversions for public water supplies and snow making can divert water from refuge streams. Expanding development can increase road density in watersheds, which can change runoff patterns from uplands into refuge streams. More residential housing requires more water for public water supply and produces more wastewater. This can modify flow patterns and introduce excessive nutrients to the streams on the refuge. Although the impacts from development on refuge water resources are relatively isolated and localized, it seems likely that these impacts will continue to expand their scope as development in Canaan Valley continues.

6.1.3 Potential for Hydraulic Fracturing Near Refuge Lands

The state of West Virginia has a long history of supporting mining and gas well exploration. Hydraulic fracturing in Marcellus shale deposits is occurring in West Virginia and has the potential to move into the Canaan Valley. Canaan Valley NWR does not own all of the mineral rights to land included in the NWR boundary (Figure 13). Therefore there is potential that additional gas wells will be developed on, or near, refuge property. If modern, high volume gas wells are developed near the refuge there is high potential for damage to aquatic resources from road construction, land clearing, and wastewater spills.

6.2 Needs and Recommendations

The primary threats to water resources at Canaan Valley National Wildlife Refuge are: 1) erosion and sedimentation associated with old logging roads and rail grades; 2) nutrient inputs and changes to runoff patterns in watersheds with residential and commercial development; and 3) possible wastewater spills associated with oil and gas well drilling on and near the refuge.

6.2.1 Inventory and assess logging roads, access roads, rail grades and skid trails

Although many of the largest rail grades and logging roads have been mapped, there are many more throughout the refuge that remain unmapped. This is particularly true in the upland areas on the valley edges. In places these old roads may be detrimentally affecting aquatic habitat by re-directing streamflow, introducing sediment to streams and wetlands, or altering the hydrologic regime of wetlands. An inventory of these features is an important first step for identifying areas that need remediation and was outlined as a strategy for meeting Objective 1.1 of the CCP (USFWS 2011).

6.2.2 Install Water Quality Monitoring Sensors in Selected Refuge Streams

Off refuge development in the southern end of the valley can affect water quality and runoff conditions in refuge streams. The scale of these impacts is not well quantified because there is little continuous water level or water quality monitoring taking place. In 2012, the Service purchased four water quality sensors for continuous measurements of temperature and electrical conductivity. Data collected with these sensors will help the Service assess existing water quality conditions and provide a reference to compare to if future development negatively impacts stream water quality or if future gas exploration results in wastewater releases.

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